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BULLETIN 583

COLORADO FERBERITE AND THE WOLFRAMITE SERIES

BY

FRANK L. HESS

AND

WALDEMAR T. SCHALLER

WASHINGTON
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COLORADO FERBERITE AND THE WOLFRAMITE SERIES.

By Frank L. Hess and Waldemar T. Schaller.

THE MINERAL RELATIONS OF FERBERITE.

By Frank L. Hess.

GEOGRAPHY AND PRODUCTION.

Ferberite, as ordinarily defined, is that mineral of the wolframite series which is composed wholly or almost wholly of iron tungstate and which, like other wolframites, crystallizes in the monoclinic system. It is comparatively rare and in most places where found it seems to occur in small quantities only. It occurs in largest quantity in Colorado, about 25 miles northwest of Denver, mainly in Boulder County, though the deposits extend a short distance southward beyond the county line into the north end of Gilpin County. From this area, which has a southwest-northeast length of about 12 miles and a width of 6 to 7 miles, an equivalent of probably 7,300 short tons of concentrates carrying 60 per cent WO_3 had been mined from 1901, when exploitation of the tungsten veins began, to the close of 1912.

The relative importance of the Boulder tungsten field, as the area is generally known, is indicated by the statistics of the production of tungsten ore in 1910, in which year the output of the field was 1,221 tons. In the same year the output of Queensland was 1,145 tons; Portugal, 1,132 tons; Argentina, 1,061 tons; and the world's production was probably about 7,500 tons, the remainder being smaller lots from many countries.[1] The tungsten-bearing mineral produced from the three countries named was wolframite, and no other country produced any considerable quantity of ferberite.

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[1] For details see Hess, F. L., Tungsten: U. S. Geol. Survey Mineral Resources, 1910, pt. 1, p. 734, 1911. Since the above paragraph was written the world's statistics for 1911 and 1912 have become available, and these show that Burma has outstripped all other producers, its output of wolframite being equivalent to 2,095 short tons of ore carrying 60 per cent WO_3. (See U. S. Geol. Survey Mineral Resources, 1911 and 1912.)

CHARACTERISTICS OF THE FERBERITE.

Ferberite occurs in the Boulder County field not only in large quantity, but in places in clean, beautifully developed crystals, and very commonly in small crystals coated with foreign material. The ferberite found over most of the field is jet black, but in a few places it is brown. It is opaque even in thin sections prepared for microscopic examination, and the clean crystals and cleavage faces are generally lustrous black.

The ferberite of Boulder County is very resistant to weathering and forms placers which have been successfully worked. The ferberite of the Black Hills (see analysis 81, pp. 32–33) decays, leaving a skeleton of hydrous iron oxide, and wolframites that are close to ferberite in composition decay similarly, but no alteration has been noted in the ferberite of the Boulder field, although it is in many places coated and discolored by hydrous iron oxide and other minerals.

The other physical characteristics accord fairly well with those given by Dana[1] for the wolframites. The cleavage along *b* is perfect, and in some specimens a parting is shown parallel to *a*, but I have not noticed the parting parallel to *t* (102) mentioned by Dana. The fracture is uneven and the mineral is brittle. Its streak and powder are dark brown—nearly black—and its hardness is about 5. Its specific gravity, as determined on selected crystals, is 7.499.

A splinter of pure material fuses to a globule which has a crystalline surface and is not magnetic. The brown mineral from the Rogers tract is almost infusible before the blowpipe, and is strongly magnetic after heating.

Although ferberite is not very soluble in acids, if it is finely powdered and boiled a few minutes with concentrated hydrochloric acid it gives a solution which, on the addition of zinc, readily shows a characteristic blue color, followed by the almost equally characteristic violet and brown.

GEOGRAPHY AND GEOLOGY OF THE BOULDER DISTRICT.

Nederland, the commercial town of the Boulder tungsten field, lies 2 miles east of Cardinal station, on the Denver, Boulder & Western Railroad, and 4 miles north of Rollinsville, on the Denver, Northwestern & Pacific Railway.

The ferberite-bearing area lies on an elevated plateau, above which, on the west, rise massive and imposing peaks. The altitude at Nederland is 8,237 feet. On the east an abrupt scarp descends from the plateau to the Great Plains. Streams draining the plateau have cut deep canyons extending back from the scarp to distances determined by the abrading power of the streams.

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[1] Dana, E. S., System of mineralogy, 6th ed., p. 983, 1909.

Biotite-hornblende granite, in some places gneissoid, granitic gneiss, and quartz-mica schist form the country rocks. The gneiss and schist are older than the granite, and all three are of pre-Cambrian age and are cut by later dikes that range in composition from limburgite to granite pegmatite.

Dynamic metamorphism has in places made the granite, gneiss, and schist difficult to differentiate. Some of the dikes are also more or less squeezed. The gneiss is believed by R. D. George[1] and Edson S. Bastin[2] to be of sedimentary origin. The pegmatites show only a little crushing and carry few metallic minerals.

OCCURRENCE, VEIN SYSTEMS, AND RELATIONS.

The ferberite occurs in a group of veins which in general extend from southwest to northeast, though individual veins strike toward nearly every point of the compass.

On the northwest and southwest sides of the tungsten-bearing area are gold and silver bearing veins having the same general trend as the tungsten veins. The veins carrying the precious metals are a continuation of the gold-bearing belt of Clear Creek and Gilpin counties.[3]

Two types of veins carry the gold and silver—those in which the minerals are mostly sulphides and those in which the gold occurs as a telluride.[4] The sulphidic veins are in general quartz veins carrying gold and silver bearing sulphides, such as pyrite, galena, chalcopyrite, and zinc blende. Silver predominates. The telluridic veins[5] occur in sheeted zones and contain only a little quartz. They carry gold mostly in a telluride, which is probably sylvanite, and the gold predominates over the silver. Pyrite, molybdenite, a vanadium mineral allied to roscoelite, barite, adularia, and chalcedony accompany the telluride. The veins are thin and commonly frozen to the walls.

The ferberite veins are more or less connected with the gold veins, as might be expected from the general grouping, and their connection with the telluridic veins seems closer than with the sulphidic veins. Specimens from Magnolia, at the southeastern edge of the field, showed both gold telluride and ferberite, but it could not be determined which was the older. George reports a like specimen in which the telluride was evidently the older mineral.[6] He also reports the occurrence of the two minerals in the Wheelmen Tunnel, in Boulder Canyon,[6] and at Sunshine, on the northern edge of the field. A specimen from Ward, still farther north and beyond the territory which up to this time has been productive, shows a wolframite which is probably not ferberite and which occurs in long, slender crystals of a habit totally different from that of the ferberite of the main tungsten area. Embedded with this mineral in white quartz are pyrite and chalcopyrite, apparently of the same general age, though the chalcopyrite is of later deposition, as it is pierced by the wolframite. The ore is said to carry both gold and silver. Although the data at hand are not very extensive, it seems probable that the connection between the three classes of veins may be fairly close and that there may not be a great difference in the ages of the several types. The manganese content of the tungsten mineral seems to increase somewhat progressively across the field from the Gilpin County line to Ward—that is, from south to north. A few miles south of the tungsten field in Gilpin County pitchblende has been found in considerable quantity in close connection with gold and silver bearing veins, which lie in the same mineral belt. Forbes Rickard has recently noted[1] a close relationship between the ferberite veins of Boulder County and the pitchblende veins of Gilpin County.

---

[1] George, R. D., The main tungsten area of Boulder County, Colo.: Colorado Geol. Survey First Rept., pp. 19-20, 1909.

[2] Oral statement.

[3] Lindgren, Waldemar, Some gold and tungsten deposits of Boulder County, Colo.: Econ. Geology, vol. 2, p. 453, 1907.

[4] Idem, pp. 456-457.

[5] Idem, pp. 457-459.

[6] George, R. D., op. cit., p. 76.

The ferberite veins much resemble those carrying gold telluride. They occur in sheeted or crushed zones and are reticulated, the individual veins ranging from a small fraction of an inch to several inches in thickness, while the ore-bearing body may reach a width of 14 feet, as in the Philadelphia mine of the Wolf Tongue Mining Co. The veins cut granite, gneiss, and pegmatite, and though the ore may extend from the granite into the gneiss it may be cut off at the contact, its continuity depending on local conditions, but there are only a few productive veins in the gneiss.

CHARACTERISTICS OF THE ORE.

The amount and character of gangue in the veins differ greatly in different parts of the field. Quartz, the universal vein mineral, occurs in much less quantity in the ferberite veins than in most veins. Only a very little visibly crystallized quartz in the ferberite veins has come to my attention. There is, however, in most if not in all of the veins of the northeastern part of the field, and in many of the wider veins of the southwestern part of the field, a very fine grained gray or brown quartz, known as "bone," which has a fracture much like that of chalcedony and which is largely a replacement of the country rock. The ferberite in the northeastern half of the field appears to be less well crystallized than in the southwestern half. It occurs in some of the veins in minute particles mixed with quartz (see Pl. VI, p. 15), so that in many places the ore is difficult to concentrate, although the

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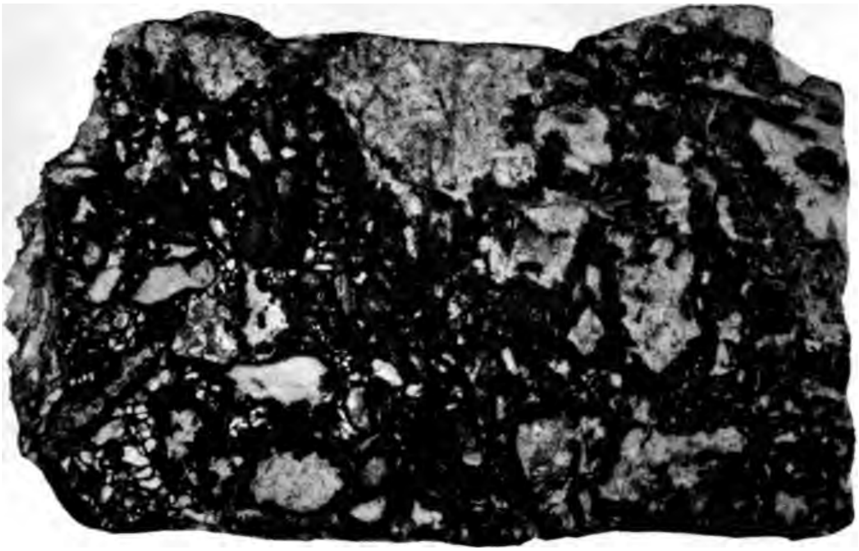
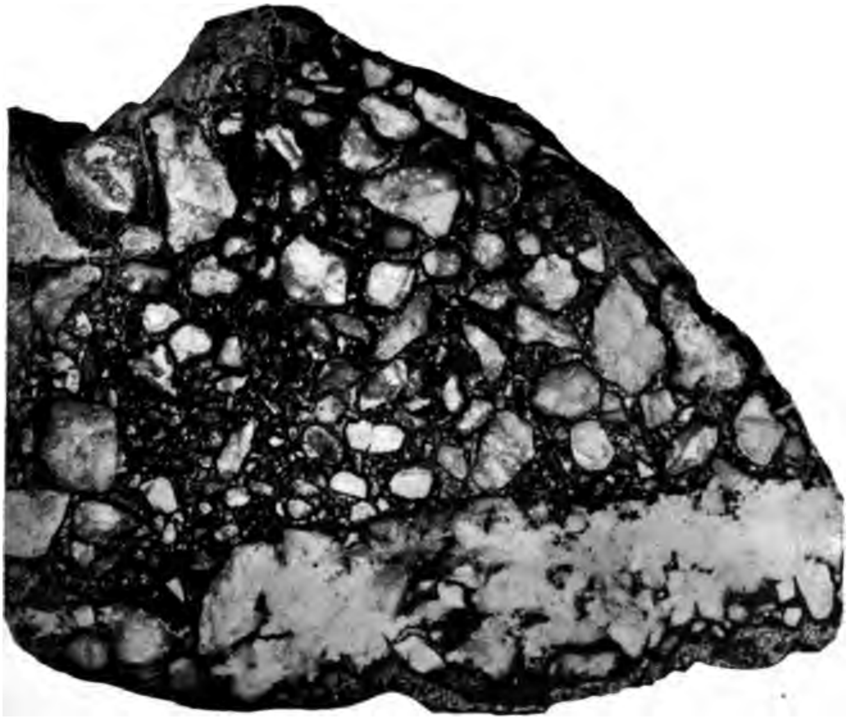
[1] Pitchblende from Quartz Hill, Gilpin County, Colo.: Min. and Sci. Press, June 7, 1913, p. 852.



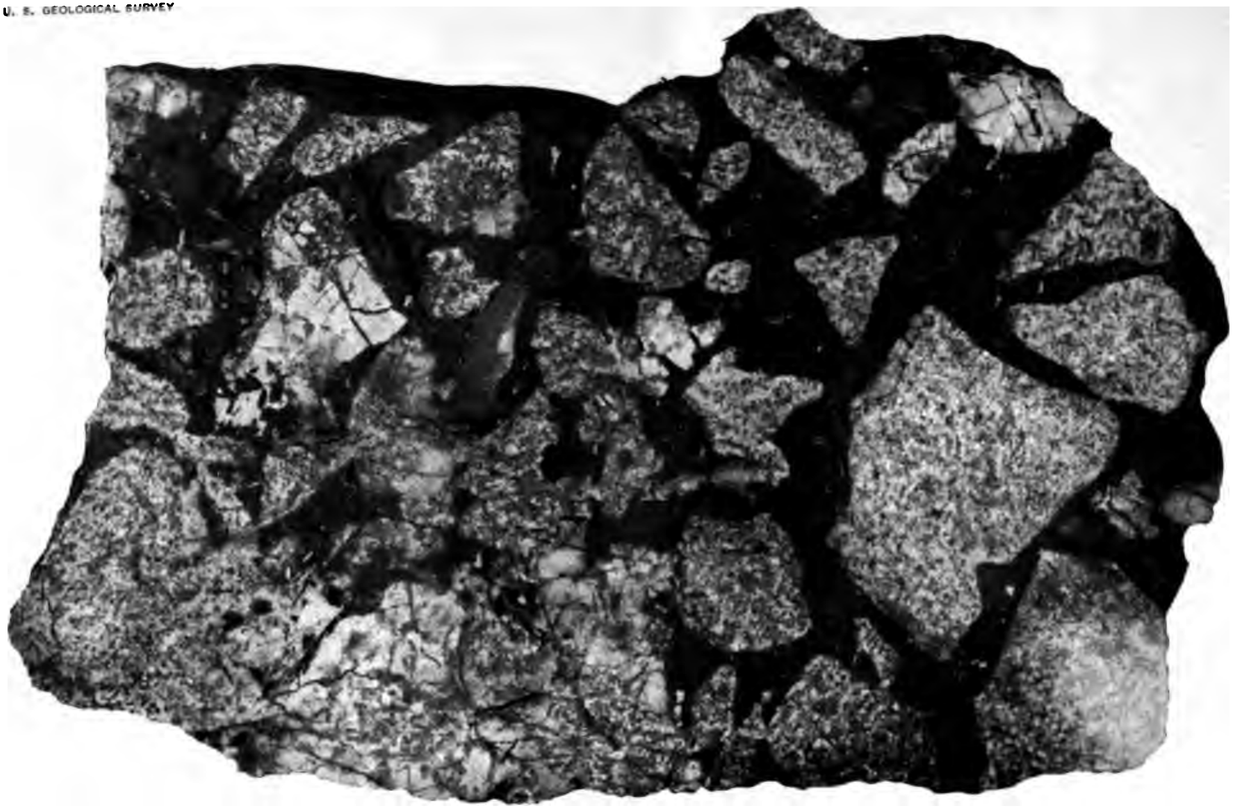
A. FERBERITE INCLOSING FINELY BRECCIATED GRANITE.

From Rogers tract, Nederland, Colo. Natural size.



B. "PEANUT ORE," FERBERITE INCLOSING FINELY BRECCIATED PEGMATITE.

From the Conger mine, Nederland, Colo. Natural size.



BRECCIATED GRANITE AND PEGMATITE CEMENTED BY FERBERITE.

Town Lot mine, Nederland, Colo. Natural size.

total percentage of WO_3 may be as high as or higher than that in ores which are easily and profitably worked.

In the southwestern part of the field the narrower individual veins are made up almost wholly of ferberite, which has grown from both sides of the crevices and forms combs of small crystals that coalesce at their bases. The combs are of fairly uniform thickness, so that although in the narrower crevices they may have met and grown together, in the wider cracks they form bristling crusts of crystals on each side. In places these crystals are clean and bright but generally very small, from one to three thirty-seconds of an inch (1 to 2 millimeters) across. Most of the crystals are covered with a coating of impure chalcedony, which in some specimens is mixed with opal and in others contains much iron. The coating generally includes small crystals of ferberite, which are of course of a later generation than those on the walls. Some vugs 3 or 4 inches across are entirely filled with such a mixture.

On the Nugget claim, 3½ miles southeast of Nederland, the crusts of nearly pure ferberite reach a thickness of more than an inch, and this claim has produced the finest crystallized specimens of ferberite yet found. In the veins of this claim, as in the others, most of the crystalline aggregates are covered with a siliceous mixture, which here carries much brown iron oxide. The veins cut a moderately coarse grained pegmatite and have so far produced only a small quantity of ore. The Winnebago, an adjoining claim, has produced some small specimens of crystallized ferberite from similar veins.

In places the country rock instead of being sheeted is crushed into smaller, more nearly equidimensional fragments, which may not be over one-eighth inch (3 millimeters) in diameter. Ore in which fragments of rock no larger than half an inch (13 millimeters) across are embedded in ferberite is popularly known as "peanut" ore, from its resemblance to peanut candy. (See Pl. I.) The fragments of the breccia vary greatly in size (Pl. II), and where the fragments are larger the breccia is characterized by vugs lined with ferberite crystals. Both finely and coarsely brecciated ore is typical of the veins of the district. Many of the veins have been opened several times, so that the ferberite itself is brecciated. (See Pls. III and IV, *B*.)

In places the ferberite carries considerable manganese and grades into wolframite. The mineral from Gordon Gulch carries almost 6 per cent MnO (analysis 58, pp. 30–31) and wolframite occurs on the north side of the field at Ward (analysis 49). The only other tungsten mineral so far identified in the field is scheelite, which occurs in small quantity as a thin coating of octahedral nearly white crystals about one thirty-second inch (1 millimeter) in thickness, over a film of ferberite covering the walls of crevices in the Sugar Loaf district in the northern-central part of the area. Vugs in ore from the Frigid Mining

Co.'s claim at Crisman are lined with clear brownish and colorless scheelite crystals, the largest three thirty-seconds of an inch (2 millimeters) thick. Vugs in ore from the Rogers tract, near the center of the area, are lined with reddish-brown scheelite, which also occurs through the quartz in small quantity. Some of the vugs are of almost microscopic size. (See Pl. V.) As seems to be usual in tungsten deposits, the scheelite formed later than the mineral of the wolframite series, but it is not a secondary mineral. In cleaning certain ferberite crystals with hydrofluoric acid deep pits with rather regular outlines are made, accompanied by the formation of yellow tungsten trioxide, and it seems possible that the pitting may be due to the removal of scheelite.

MINERALS ASSOCIATED WITH THE FERBERITE.

Associated minerals, other than quartz, are few and scarce in the ferberite veins of the main part of the field. Near the gold-silver bearing areas there is of course a mixture of the minerals of the several vein groups.

The following minerals accompany ferberite in the veins:

Adularia.—Adularia forms a coating one-sixteenth of an inch (2 millimeters) thick on the walls of the Black Hawk No. 2 vein, 1¼ miles south of Nederland. It is beneath most of the ferberite, but was probably deposited with the first of the ferberite. Adularia in microscopic grains is found in many of the veins.

Calcite.—The gangue in the Conger mine carries microscopic particles of a carbonate, which is probably calcite.

Chalcedony.—Chalcedony mixed with more or less opal and hydrous iron oxide coats crystals from many of the veins.

Chalcopyrite.—Chalcopyrite occurs at Ward in veins carrying some wolframite, which seems to approach ferberite in composition, though no analysis of the mineral is at hand.

Galena.—George[1] reports the occurrence of galena and sphalerite in veins with ferberite near Magnolia. The galena is said to occur generally in minute cubes but in considerable quantity.

Gold and silver.—Gold and silver are reported to occur in some of the ferberite veins other than those in which sylvanite is present. In the ore seen which is said to be gold-bearing small quantities of sulphides are present and the gold is probably associated with the pyrite. Hills[2] states that eight assays of concentrates gave an average of 0.01 ounce of gold to the ton.

Greenawalt[3] gives three analyses of concentrates which carried silver in quantities of 1.2, 2.4, and 3.1 ounces to the ton. The speci-

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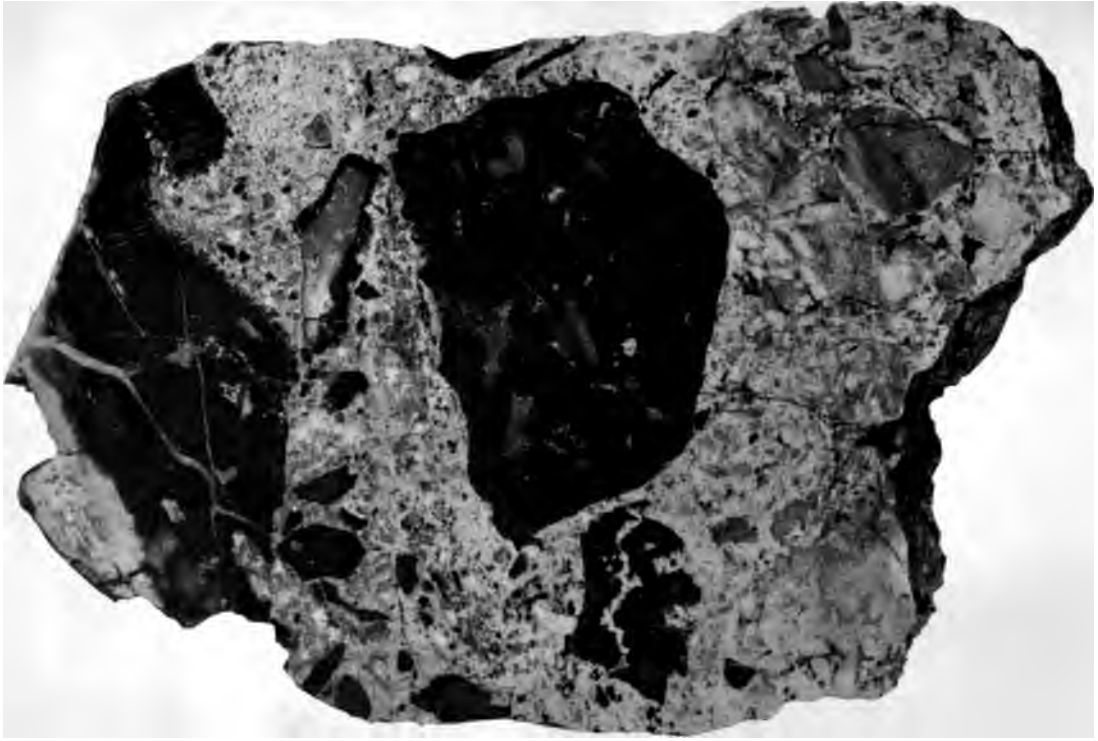
[1] George, R. D., The main tungsten area of Boulder County, Colo.: Colorado Geol. Survey First Rept., p. 75, 1909.

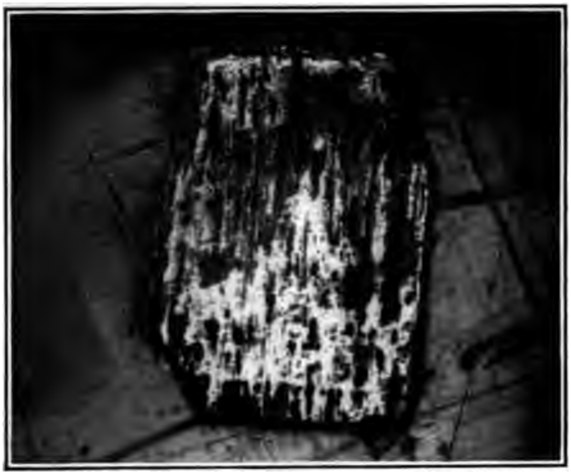
[2] Hills, V. G., Tungsten mining and milling: Colorado Sci. Soc. Proc., vol 9, p. 150, 1909.

[3] Greenawalt, W. E., The tungsten deposits of Boulder County, Colo.: Eng. and Min. Jour., vol. 83, p. 977.



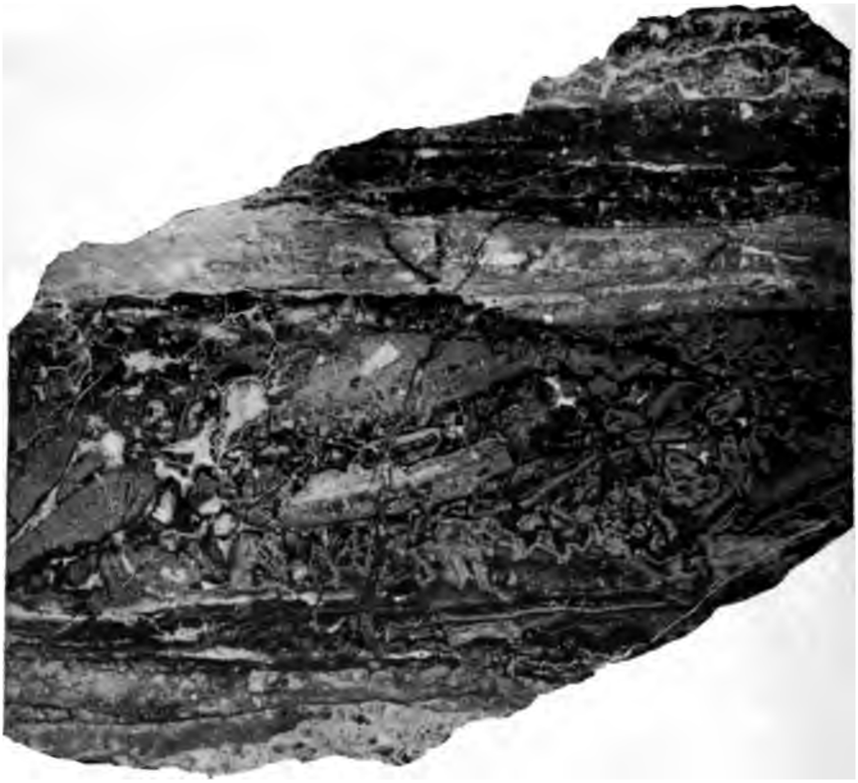
BRECCIATED FERBERITE VEIN.

Shows crystals formed since brecciation. Conger mine, Nederland, Colo. Natural size.



A. CUT AND POLISHED CRYSTAL OF BROWN FERBERITE.

From Winnebago claim near Rollinsville, Colo. Shows spongy structure of the ferberite, the pores of which are filled with hydrous iron oxide. × 78.



B. BRECCIATED FERBERITE VEIN.

From the Conger mine, Nederland, Colo. Both the black and the gray edging it are ferberite, the difference in color being due to the orientation of the crystals. Natural size.

mens came respectively from Beaver Creek, Nederland, and Gordon Gulch. Tomblin[1] states that in the Logan mine at Crisman free gold is sometimes found with ferberite.

The occurrence of small quantities of gold and silver in tungsten veins is fairly common, but in many if not most veins the precious metals, though of the same general period of vein formation, are probably of later deposition than the wolframite.

Silver seems to occur in greater quantity with the wolframites than does gold, and gold in greater proportional quantity with scheelite, but this can not be stated as an invariable rule.

Hübnerite is found near Pony, Mont., in quartz veins which have been worked for silver; in veins prospected for silver but not rich enough to work near Ellsworth, Mammoth district, Nye County, Nev. (the name hübnerite was given by Riotte to the mineral from this place); at Butte, Mont.,[2] on the 300-foot level of the Gagnon mine, where hübnerite "formed an oreshoot of argentiferous material;" in the Birdie mine 4 miles east of Butte (of very light brownish-yellow color);[3] with silver minerals in the Combination mine, Philipsburg, Mont.;[4] in the mines of Silverton, Colo.[5] (wolframite also); and Tonopah, Nev.[6] Wolframite occurs with silver ore in the Tip Top mine, Tip Top district, near Columbia, Ariz.; in a prospect of A. C. Young's at Old Hachita, N. Mex.;[7] in the Victorio district, N. Mex.;[8] in the Sonoma Range, 15 miles south of Golconda, Nev.; at Silver Mines, 10 miles southeast of Ironton, Mo.;[9] and on the Silver Comet and other claims southwest of Pioche, Nev. Wolframites are also found with deposits carrying more gold than silver in the South Homestake mine, White Oaks, N. Mex.;[10] gold quartz veins on Sheep Creek near Salmo, British Columbia;[11] and gold mines of Lead, S. Dak.; and at Cave Creek, Ariz., auriferous pyrite occurs with ferberite.

---

[1] Tomblin, M. B., Tungsten; history, occurrence, uses: Facts concerning tungsten mining in world's greatest field, Boulder County, Colo.: Boulder County Metal Mining Association Bull. No. 3, 1912.

[2] Weed, W. H., Geology and ore deposits of the Butte district, Mont.: U. S. Geol. Survey Prof. Paper 74, p. 80, 1912. See also, Pearce, Richard, The association of minerals in the Gagnon vein, Butte City, Mont.: Am. Inst. Min. Eng. Trans., vol. 16, p. 64, 1888.

[3] Tomek, F., Tungsten in Montana: Min. World, vol. 28, p. 68, 1908.

[4] Goodale, C. W., and Akers, W. A., Concentration before amalgamation for low-grade partially decomposed silver ores, with notes on the geology of the Flint Creek mining district: Am. Inst. Min. Eng. Trans., vol. 18, p. 248, 1890.

[5] Ransome, F. L., A report on the economic geology of the Silverton quadrangle, Colo.: U. S. Geol. Survey Bull. 182, pp. 86–87, 256, 1901.

[6] Eakle, A. S., The minerals of Tonopah, Nev.: California Univ. Dept. Geology Bull., vol. 7, 1912, p. 18. Prof. Eakle calls the mineral wolframite, but states "some of them [the crystals] are exceedingly thin and almost transparent, with a deep-red color." This corresponds with a specimen in my possession and seems to indicate hübnerite rather than wolframite.

[7] Lindgren, Waldemar, and others, The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, p. 336, 1910.

[8] Idem, p. 292.

[9] Haworth, Erasmus, A contribution to the Archean geology of Missouri: Am. Geologist, vol. 1, pp. 294–295, 1888.

[10] Graton, L. C., U. S. Geol. Survey Prof. Paper 68, p. 180, 1910. See analyses 4 and 16, p. 24.

[11] Walker, T. L., The occurrence of tungsten ores in Canada: Canadian Min. Inst. Jour., vol. 11, pp. 367–371, 1908; Report on the tungsten ores of Canada: Canada Dept. Mines, Mines Branch, p. 37, 1909.

In 1907 a lot of wolframite ore, weighing 1.1 long tons, from Ravensthorpe, Western Australia, carried 66.2 per cent WO_3 and yielded 5.3 ounces of gold.[1]

Examples might be multiplied but would add little weight. The importance of those given lies in their bearing on the genesis of tungsten, gold, and silver ores. In many places tungsten ores are closely connected with pegmatites or lie in the pegmatites themselves and are probably in nearly all places close to a magmatic source. The gold and silver found in the deposits must be likewise near their place of origin. Of course, it is not to be argued that the absence of tungsten minerals implies that the gold and silver may not be near a magmatic source, but gold and silver appear to accompany siliceous solutions much farther from their igneous source than do tungsten minerals. It seems probable that the tungsten minerals may be deposited from the hotter waters emanating from magmas, and silver and gold from the solutions after they have somewhat cooled.

Hamlinite (?).—In sections cut for microscopic study from a specimen obtained at the Eagle Rock mine many small, very light green fragments of a uniaxial, optically positive mineral were found. As determined by E. S. Larsen, its indexes of refraction are $\omega = 1.620 \pm 0.003$, $\epsilon = 1.630 \pm 0.003$. Its birefringence is 0.010, but some basal sections show anomalous birefringence as though divided into segments. It has a perfect basal cleavage and shows a slight zonal growth. The particles show a tendency toward square sections, and the optical properties suggest that the mineral belongs to the alunite-hinsdalite series. Although very small, the particles are numerous, forming perhaps 10 to 25 per cent of the bulk of this particular ore. (See Pl. VI.) The gangue is "horny" quartz through which are distributed particles of ferberite and certain other particles which are attracted by a magnet, probably magnetite, both of which occur in grains almost as small as the unknown mineral. An attempt was made to separate the mineral from its gangue by grinding it very fine and passing the powder through a Thoulet solution of 2.8 specific gravity, but the material was too much mixed with quartz to show sufficient improvement for analytical purposes. The fact that with the attached quartz it sank through the liquid indicates that its specific gravity is above 2.8, but it is probably not over 3. A partial analysis by George Steiger, in the chemical laboratory of the United States Geological Survey, showed the presence of aluminum, 2 per cent strontium, a very little sulphur as a sulphate, and 3.6 per cent phosphorus pentoxide. The only heavy metals found were tungsten, iron, manganese, and a trace of titanium. Fluorine and chlorine were absent. There was only a questionable trace of calcium and a very small quantity of magnesium.

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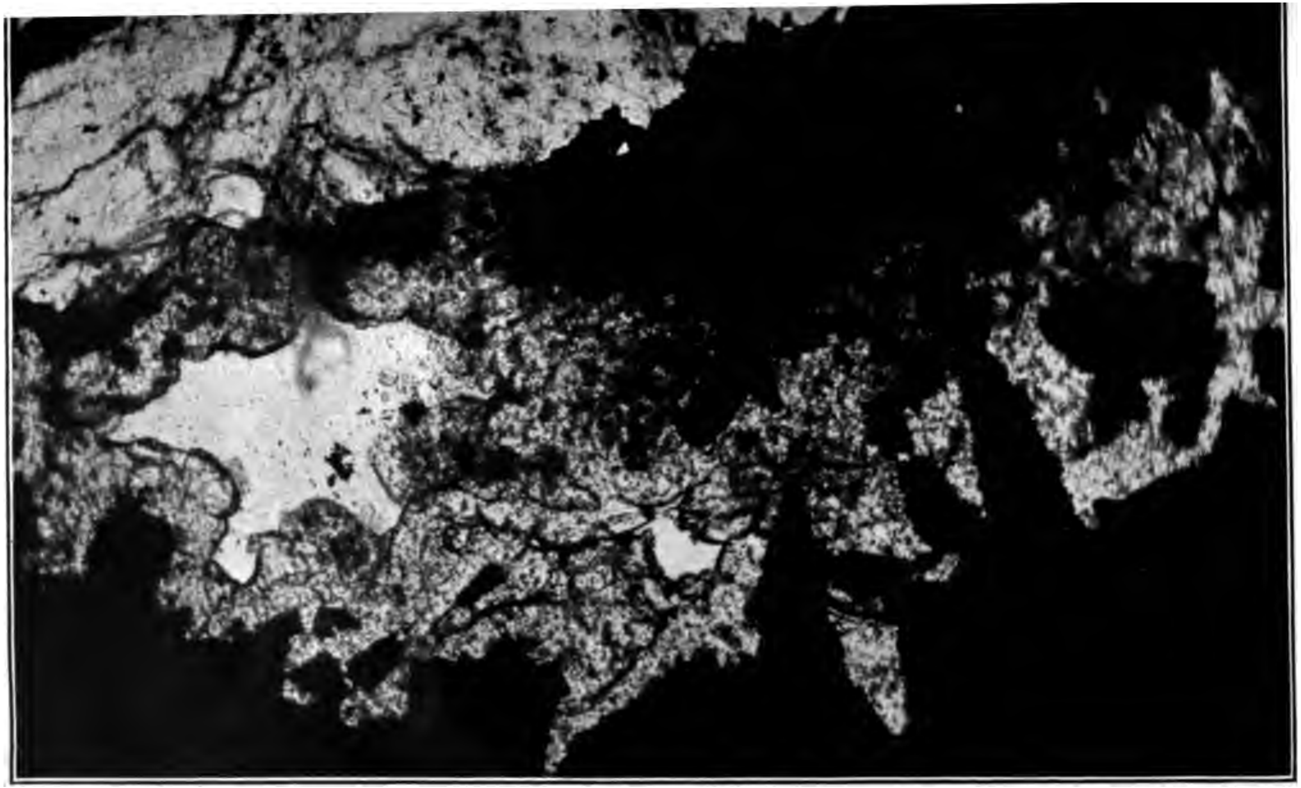
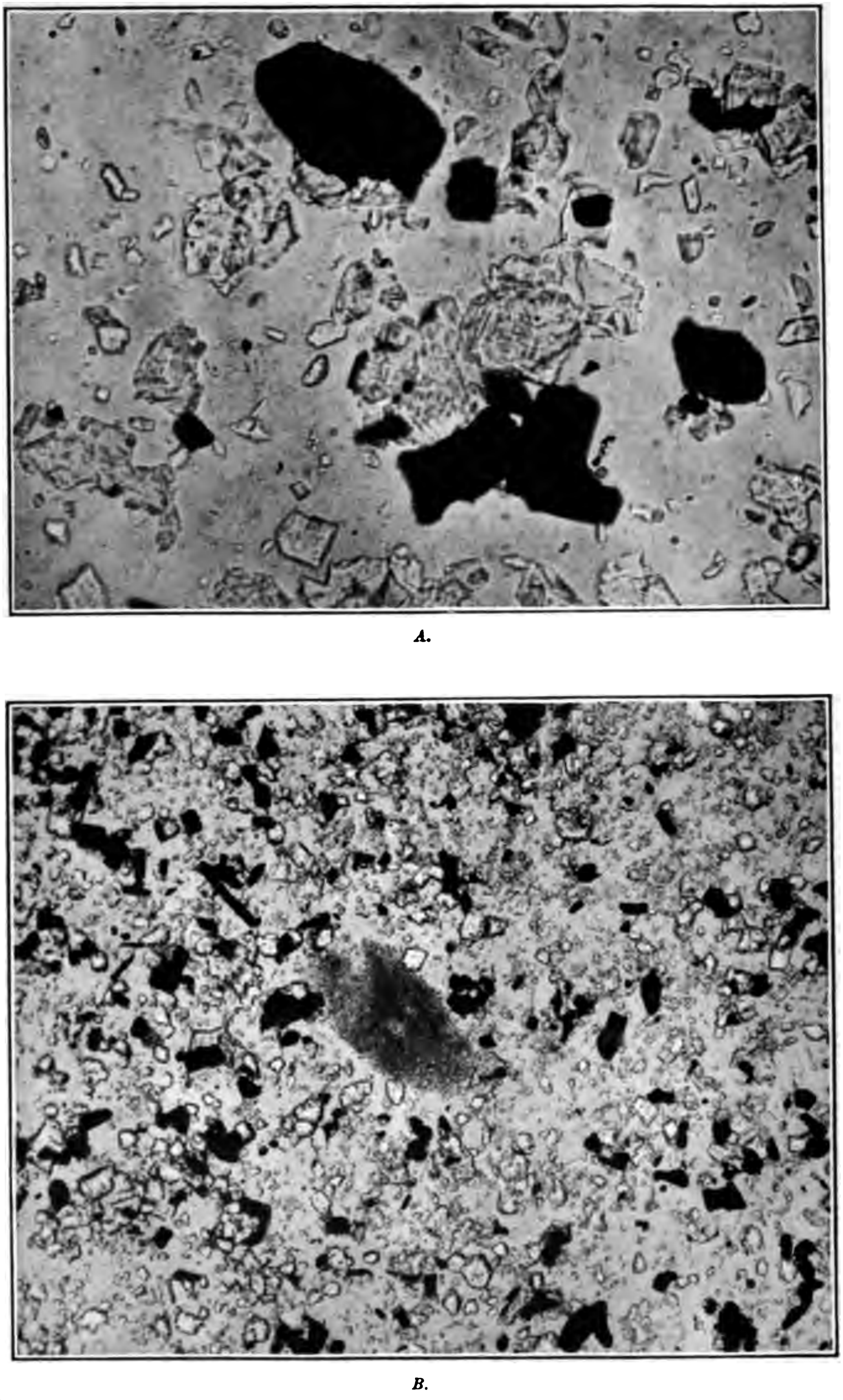
[1] Simpson, E. S., and Gibson, C. G., The distribution and occurrence of the baser metals in Western Australia: Western Australia Geol. Survey Bull. 30, pp. 115–117, 1907.



VUG IN FERBERITE VEIN NEARLY FILLED BY SCHEELITE, THE CAVITY THEN REMAINING BEING FILLED BY QUARTZ.

The black is ferberite, the gray mottled area is scheelite, and the nearly white is quartz. × 100.



A.

B.

THIN SECTIONS OF ORE SHOWING HAMLINITE.

rom Eagle Rock Mine, 8 miles west of Boulder, Colo. Groundmass, quartz. Mineral with high relief, *hamlinite* (?) Black mineral, ferberite. × 380.

The mineral seems to be close to hamlinite, for which the formula, as recalculated by Prior,[1] is $2SrO.3Al_2O_3.2P_2O_5.7H_2O$, but as a little sulphur is present it probably belongs in the series between hamlinite and svanbergite ($2SrO.3Al_2O_3.P_2O_5.2SO_3.6H_2O$). Another mineral of the same group, hinsdalite ($2PbO.3Al_2O_3.P_2O_5.2SO_3.6H_2O$), was discovered in 1910 by Larsen [2] as a vein mineral in the Golden Fleece mine, near Lake City, Colo.

The same mineral has been found in sections from other parts of the Boulder field, though not in such large quantity as in the Eagle Rock specimen. Sections of "hornstone" ore from other places have shown none of it. However, phosphorus in small quantity is nearly if not quite a universal component of the Boulder County tungsten ores.

Hugh F. Watts, who has assayed thousands of samples of ferberite ores and concentrates coming from all parts of the Boulder field, states that whenever he has tested for it he has found phosphorus present.[3] In one test on a composite of seven ores the phosphorus present amounted to 0.038 per cent. Hills [4] notes from 0.01 to 0.02 per cent phosphorus in eight out of nine analyses of concentrates and a trace in the other. Greenawalt [5] notes 0.05 per cent in a concentrate from Gordon Gulch. No apatite or other phosphate except the hamlinite (?) has been found, and it seems reasonable to suppose a very wide distribution of the hamlinite (?). The mineral apparently occurs only in the quartz gangue, and if the ore is finely ground before separation very little will be left in the concentrates, for its specific gravity (more than 2.8 and probably not higher than 3) is so low that it would readily pass into the tailings.

I hope to make further investigation of this mineral.

Hematite (*specular*).- At the south end of the Black Hawk No. 1 vein, 1¾ miles south of Nederland, a short vein which is nowhere more than a few inches thick, the ferberite gives way to specular hematite. This mineral is also found in small quantity in some other veins, and what is known as the May vein, a short distance east of the Black Hawk No. 1 vein, is a series of anastomosing veinlets made up of specular hematite, which is said to be accompanied by a little tungsten, though none could be found in specimens collected. Hills [4] gives an analysis of ferberite concentrates from "the east side of the district," in which the content of FeO exceeds that of WO_3, and another in which the quantity of FeO is only a little less than that of WO_3. The analyses follow.

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[1] Prior, G. T., Hamlinite, plumbogummite (hitchcockite), beudantite, and svanbergite, as members of a natural group of minerals: Mineralog. Mag., vol. 12, p. 253, 1900.

[2] Larsen, E. S., and Schaller, W. T., Hinsdalite, a new mineral: Am. Jour. Sci., 4th ser., vol. 32, p. 251, 1911.

[3] Private communication.

[4] Hills, V. G., Tungsten mining and milling: Colorado Sci. Soc. Proc., vol. 9, p. 149, 1909.

[5] Greenawalt, W. E., The tungsten deposits of Boulder County, Colo.: Eng. and Min. Jour., vol. 83, p. 951, 1907.

Analyses of tungsten concentrates treated at the Clarasdorf mill, near Boulder, Colo.

	1	2
Tungsten oxide	38.46	38.59
Iron oxide	39.31	34.01
Iron sulphide	.51	2.59
Sulphur	.27	1.38
Manganese oxide	3.10	2.67
Phosphorus	.01	.01
Silicon dioxide	18.61	22.13

The first analysis indicates a wolframite of the composition $MnWO_4$, 26 per cent; $FeWO_4$, 74 per cent—a composition close to that of the Gordon Gulch wolframite (analysis No. 58, p. 31). After satisfying the MnO present only 8.8 of the 39.31 per cent FeO given is required to combine with the WO_3. The second analysis indicates a wolframite of the composition $MnWO_4$, 22.7 per cent; $FeWO_4$, 77.3 per cent. This composition requires for combination with WO_3 only 8.7 of the 34.01 per cent FeO. The form in which the iron is present is unknown, but the possibility that it may be specular hematite is at once suggested by knowledge of the occurrences mentioned. The sulphur shown in the analyses indicates, of course, that a small quantity of iron is present as pyrite.

Occurrences of specular hematite with wolframites are not unknown. At South Crofty mine, Cornwall, "the presence of specular iron has caused trouble in obtaining a high-class wolfram concentrate."[1]

It seems probable that deeper workings on the Rogers tract may show specular hematite, to the decomposition of which may be due the brown color of much of the ferberite from that tract.

Limonite.—Limonite, under which term are here included all hydrous oxides of iron, occurs in many veins, and nearly all the ore on the Rogers tract, about 2 miles northeast of Nederland, is stained brown with it. The crystals of ferberite are not only brown on the outside, but when broken show brown sections. (See p. 38 and Pl. IV, *A*, p. 13.) The origin of the limonite and its relationship to the ferberite are unknown, but in part at least it is possibly altered from specular hematite, as already stated. Iron-bearing carbonates occur in some tungsten deposits, notably the scheelite deposits of Atolia, Cal. Carbonates decompose much more easily than specular hematite, and one may have been originally inclosed in the ferberite of the Rogers tract and some other places.

Magnetite.—Magnetite is recorded by George[2] as occurring with the ferberite. Magnetite seems to be a probable associate of ferberite, but in several specimens of powdered ferberite examined I have not been able to separate it with a horseshoe magnet nor to find it by microscopic examination with reflected light in polished and etched specimens from the Western Star and Nugget claims. In the ore from the Eagle Rock mine, however, a small quantity of magnetic material which is probably magnetite was found.

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[1] Anon., Cornwall (editorial): Min. Mag., London, vol. 8, p. 165, 1913.

[2] George, R. D., The main tungsten area of Boulder County, Colo.: Colorado Geol. Survey First Rept., p. 75, 1909.

Molybdenite.—George[1] and Lindgren[2] report, though Lindgren doubtfully, that molybdenite occurs with the ferberite in Boulder County. I have not seen this association. Molybdenite is a common associate of wolframite in Queensland[3] and is also found with it in Saxony[4] and England,[5] but the association is rare in this country, though molybdenite occurs with wolframite and tourmaline on the Black Horse claims, 10 miles southeast of Daisy, Stevens County, Wash., and in small quantity with ferberite at Cave Creek, Ariz.

Opal.—Opal mixed with chalcedony and a little limonite forms a thin opaque yellowish-gray coating on ferberite crystals in the Black Hawk No. 1 vein, 1½ miles south of Nederland, and is probably a constituent of the siliceous coating on the ferberite from other mines.

Pyrite.—Pyrite is rare, except where the ferberite veins approach the gold and silver veins, though here and there a little may be found. At one place in the Conger mine a vein of pyrite 2 inches thick cut across the ferberite veins. Iron sulphide in quantities reaching 3.25 per cent[6] is indicated by analyses of concentrates from a number of places, as noted under hematite.

Quartz.—Quartz occurs in all veins in comparatively small quantity. In most places it is so finely granular that it has a fracture like chalcedony. Very little of it shows crystal form.

Scheelite.—For discussion of the occurrence of scheelite see pages 11–12.

Sphalerite.—Sphalerite is noted by George (see Galena, p. 12), and Moses[7] states that he found small yellow crystals upon ferberite specimens from the Boulder field.

Sylvanite.—As has been noted, sylvanite occurs with ferberite at Magnolia. George[8] also notes this association in the vein exposed by the Wheelmen Tunnel in the lower part of the canyon of Boulder Creek and in a mine near Sunshine.

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[1] George, R. D., The main tungsten area of Boulder County, Colo.: Colorado Geol. Survey First Rept., p. 75, 1909.

[2] Econ. Geology, vol. 2, p. 461, 1907.

[3] Cameron, W. E., Wolfram and molybdenite mining in Queensland: Queensland Geol. Survey Rept. 188, 13 pp., 1904.

[4] Beck, R., Über ein kürzlich aufgeschlossenes Wolframerzgangfeld und einige andere neue Aufschlüsse in sächsischen Wolframerzgruben: Zeitschr. prakt. Geologie, vol. 15, pp. 38, 40, 1907.

[5] Finlayson, A. M., The ore-bearing pegmatites of Carrock Fell and the genetic significance of tungsten ores: Geol. Mag., vol. 7, pp. 19–28, 1910.

[6] Hills, V. G., Tungsten mining and milling: Colorado Sci. Soc. Proc., vol. 9, p. 149, 1909.

[7] Moses, A. J., The crystallization of luzonite and other crystallographic studies: Am. Jour. Sci., 4th ser., vol. 20, p. 282, 1905.

[8] Op. cit., p. 76.

SPECTROSCOPIC EXAMINATION OF THE FERBERITE.

Scandium,[1] columbium, tantalum, and other rare elements are found in some wolframites, and a specimen of ferberite from the Conger mine was sent with a specimen of scheelite to Prof. G. Eberhard, Potsdam, Germany, who kindly made a spectroscopic analysis of them. In a letter dated August 20, 1912, to Adolph Knopf, of the United States Geological Survey, Prof. Eberhard says:

> The examination of the two minerals from Mr. Hess gave the following results:
>
> The lines of Ba, Gl, Pb, Ga, K, Li, Na, Ni, Ag, Sn, Bi, Zn, and Zr are absent in both minerals. The lines of the following elements are present in ferberite:
>
> Al, visible.
> Ca, weak.
> Cr, weak or absent.
> Fe, strong.
> Cb, weak.
> Cu, weak.
> Mg, visible.
> Mn, weak.
> Mo, weak?.
> Sc, weak.
> Si, strong.
> Sr, weak.
> Ti, weak.
> V, weak.
> W, strong.
> Y, absent.
>
> I have not sought for the elements not here listed. Lines marked "weak" indicate that the content of the element is small or very small. Lines marked "visible" indicate that the content of the element is fairly large. Lines marked "strong" indicate that the content of the element is large. The element whose presence I could not substantiate with absolute certainty I have marked with a question. The content of scandium is certainly smaller than 0.005 per cent and is therefore chemically not detectable.

Since this determination was made an article by H. S. Lukens[2] has appeared, in which he describes the extraction of scandium from residues of Colorado tungsten ores that had been treated by the General Electric Co. at Schenectady, N. Y. Lukens found 0.05 per cent of scandium oxide in the residues. In reply to my inquiries the Primos Chemical Co., which had furnished the ores, wrote, under date of April 18, 1914:

> Regarding the scandium found in some of our ores, we have not yet located the point from which the ores come, but as a rule our residues contain no scandium. A great many tests are made right along. As we are getting ores from a great many points on our property, it is very difficult to tell from which particular openings they came. Most Boulder County ores contain no scandium. Have given samples right along to various universities, including the University of Pennsylvania, and though exhaustive tests have been made, not one of them has found any scandium.

Another letter, dated April 27, 1914, says:

> As far as our records show, we shipped, with the probable exception of one small lot from Arizona, only Boulder County ores to the General Electric Co.

No tungstic ocher, muscovite, stibnite, bismuth minerals, fluorite, tourmaline, axinite, cassiterite, or topaz—minerals which in some places occur with wolframite deposits, particularly if closely connected with pegmatites—are known to have been found in the Boulder field.

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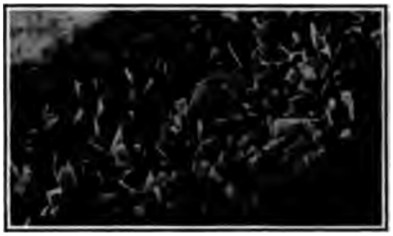
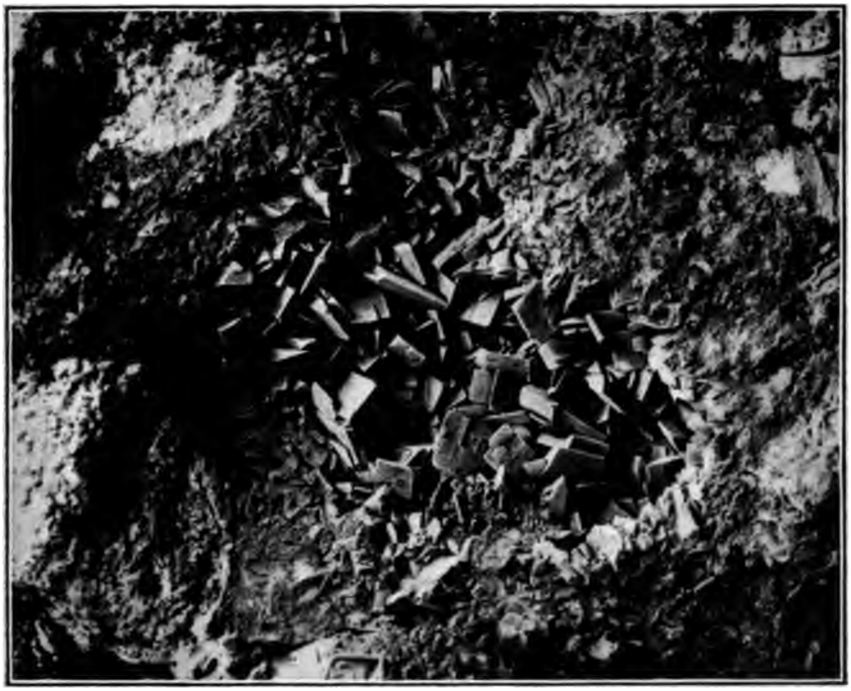
[1] Winter Herbert, Ueber Vorkommen und Reindarstellung des Scandiums: Inaugural-Dissertation, Friedrich-Wilhelms-Universität zu Berlin, pp. 22-23 et al., 1911. See also Mennicke, Hans, Die Metallurgie des Wolframs, pp. 111 et seq., 1911.

[2] Scandium in American wolframite: Am. Chem. Soc. Jour., vol. 35, pp. 1470-1472, 1913.



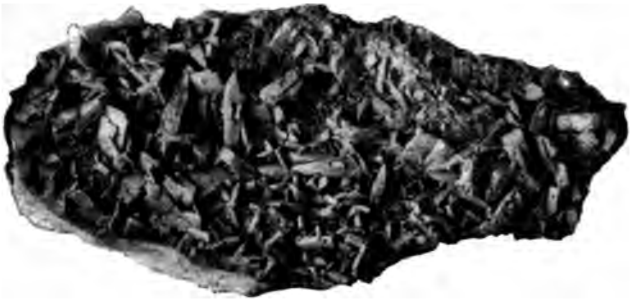
A. WEDGE-SHAPED FERBERITE CRYSTALS FROM THE LONE TREE MINE, NEDERLAND, COLO.

Fan-shaped intergrowth in right center. Coated with ammonium chloride. × 2.



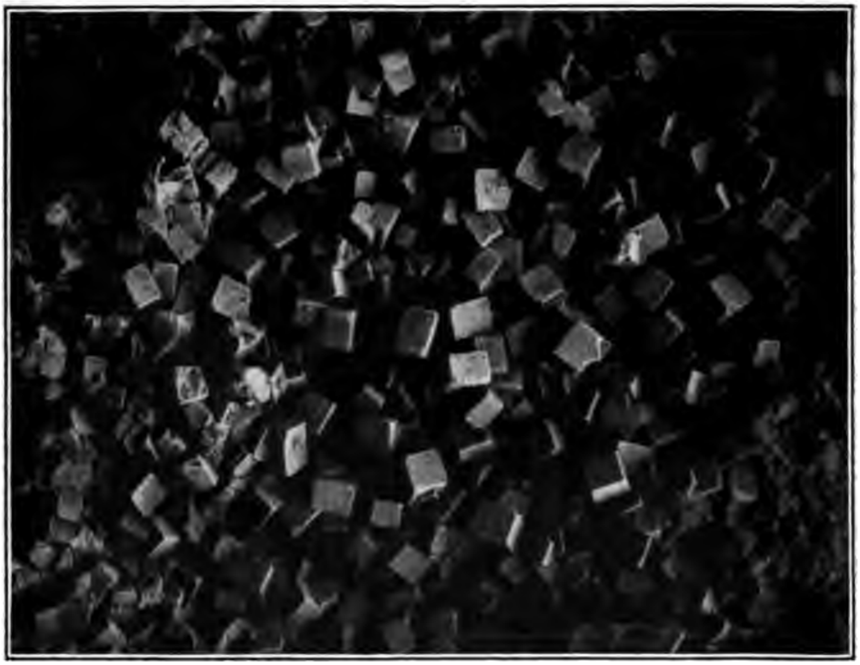
B. WEDGE-SHAPED FERBERITE CRYSTALS FROM THE HOOSIER MINE, NEDERLAND, COLO.

Fan-shaped intergrowth and twins in lower right center. Coated with ammonium chloride. × 2.



A. CRYSTALLIZED FERBERITE FROM THE "CROW PATENT," NEDERLAND, COLO.

The crystals are attached by the *c* axis and show penetration twins and reentrant angles. Coated with ammonium chloride. Natural size.



B. CRYSTALLIZED FERBERITE FROM THE GEORGIA A. MINE, NEDERLAND, COLO.

Coated with ammonium chloride. × 10.

CRYSTALLIZED FERBERITE.

As has been stated, the ferberite commonly occurs in definite crystal forms and the beauty of the crystals is unique. However, although crystals are common, good specimens suitable for display in museums are very rare, for most of the crystals are so small that they appear insignificant; they are very fragile and are easily broken in mining; and in many places they are coated with mixtures of chalcedony, opal, and hydrous iron oxides in varying proportions. This coating may be removed from some specimens without serious injury by treatment with hydrofluoric and sulphuric acids, but crystals so treated show uneven surfaces when an attempt is made to measure them with a goniometer.

Probably a wedge shape is the commonest form of the crystals. This form occurs in many of the mines. One of the best specimens seen is from the Hoosier mine, between 1 and 2 miles northeast of Nederland (Pl. VII, *B*). The wedge shapes are formed by the terminations at the ends of the *b* axis and most of the crystals are attached at one end of this axis. Some crystals are intergrown in such a way as to produce a fan shape (Pl. VII, *A* and *B*). In a few specimens crystals attached by one end of the *c* axis are prominent, in which case the termination at each end of the *b* axis is shown. Some of the crystals show penetration twins, extending through *c*{001}. Around the penetrating crystal in two or three occurrences there seem to be reentrant angles in the penetrated members (Pl. VIII, *A*). The specimen illustrated came from a tract of land known as the Crow patent, near Nederland.

In a specimen from the Georgia A. claim the crystals are almost cubic and about one one-hundredth inch (0.25 millimeter) across. Plate VIII, *B*, represents the specimen magnified 10 diameters.

Another form of crystal is found on the Nugget and the Winnebago claims, near Rollinsville, Gilpin County. In this form the crystal presents a face (*b*) which is a long, narrow rhomb, with a length of about three-eighths inch (9.4 millimeters) and a width one-tenth to one-fifth as much. Typical specimens are shown in Plates IX and X. In some specimens the rhomb has sides much more nearly of equal length. (See Pl. XI.) Plate XII shows a very fine specimen with peculiar, irregular faces. The crystal forms are described at length by W. T. Schaller in the latter part of this bulletin.

COMPOSITION OF FERBERITE AND OTHER MEMBERS OF THE WOLFRAMITE SERIES.

The original ferberite was found in the Sierra Almagrera, in southern Spain, and is stated by Liebe[1] to have been named by Breithaupt for R. Ferber, of Gera. Liebe made an analysis of the mineral. (See analysis No. 79, pp. 32–33.)

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[1] Liebe, K.L.H., Ein neuer Wolframite, ein Beitrag zu Mineral Chemie: Neues Jahrb., 1863, pp. 540–552.

The next year Rammelsberg[1] published an article on ferberite with an analysis of his own material (see analysis No. 82) from the same locality as that described by Liebe. He quotes Liebe's analysis and shows that the iron oxide and tungsten trioxide are not in a simple ratio and that there is an excess of iron oxide. Neither mineral was pure, and the analyses are not very satisfactory, so that calculation of iron in excess is uncertain, for it was probably present as an impurity and not as a part of the mineral. Liebe deducted 1.39 per cent limonite from his analysis.

It seems certain that the calcium present should be calculated as scheelite, for scheelite almost always if not invariably accompanies other tungsten materials. It is not visible in all specimens to the unaided eye, but microscopic examination generally shows it as interstitial, inclosed in the wolframite crystals, filling vugs, or occurring separately in the deposit. (See Pl. V, p. 14, and Pl. XIII, *A* and *B*, p. 30.)

Some magnesium was found, but this element is not known to be a constituent of tungsten minerals, although A. M. Finlayson[2] gives an analysis of scheelite from Donaldsons, New Zealand, containing 0.2 per cent MgO, which he considers to be combined with WO_3, taking the place of CaO, and Damour[3] considered that both calcium and magnesium might take the place of iron or manganese in wolframite. That magnesium takes the place of either calcium or iron in tungsten minerals seems to me altogether unlikely. If it did so, some pure tungsten mineral—that is, some mineral which could be shown by microscopic or other examination not to contain particles of other substances—would probably be found in which the magnesium would form a considerable part of the mineral, just as do those elements known to form natural tungstates—namely, calcium, copper, iron, lead, and manganese. Therefore, in recalculating these and other analyses on pages 24–35, neither magnesium nor calcium has been considered as belonging to the wolframite.

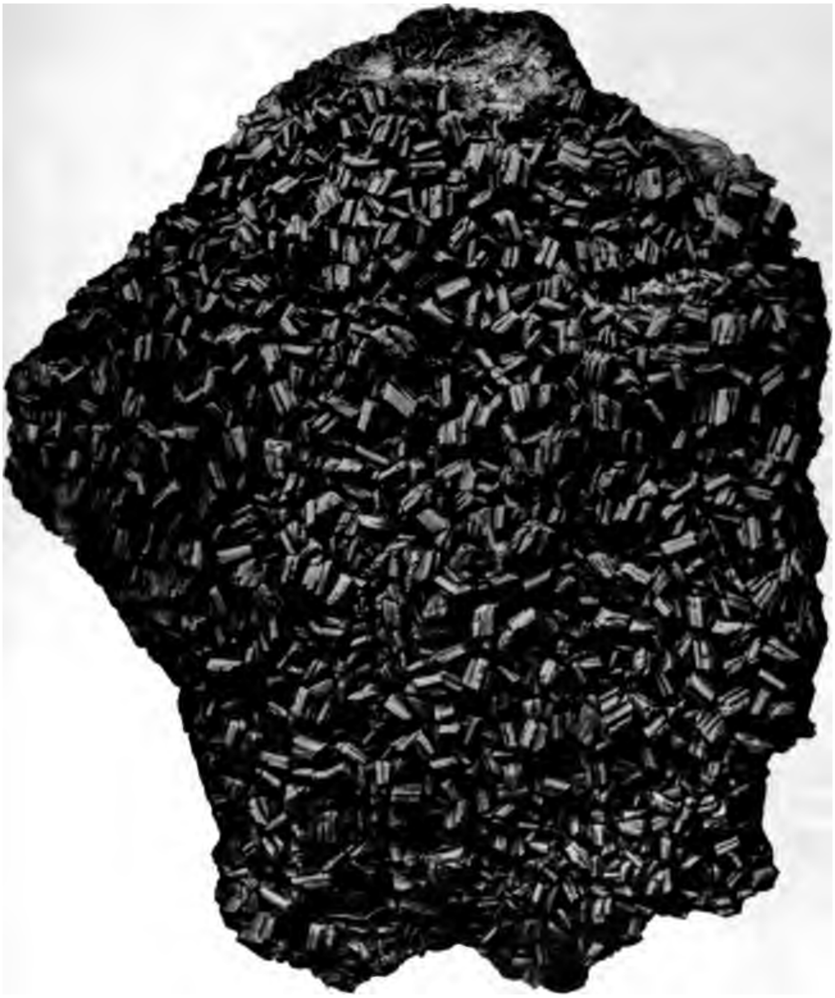
To obtain a basis for differentiating ferberite from the remainder of the wolframite group all the analyses of wolframites (by which term is meant all members of the iron-manganese tungstate series) available to the author have been collected for comparison. More than 300 analyses were examined, but of these some represented ores rather than minerals; in many the WO_3 had been determined by difference, which amounts to little more than a guess; in some the figures gave evidence that either the analytical work was bad or that the material was so impure that no proper comparison of the results would be possible. Where several analyses of the same material were obtained, only one has been tabulated.

---

[1] Rammelsberg, C. F., Über die chemische Zusammensetsung des Ferberite: K. Akad. Wiss. Berlin Monatsber., Jahre 1864, pp. 175–176, 1865.

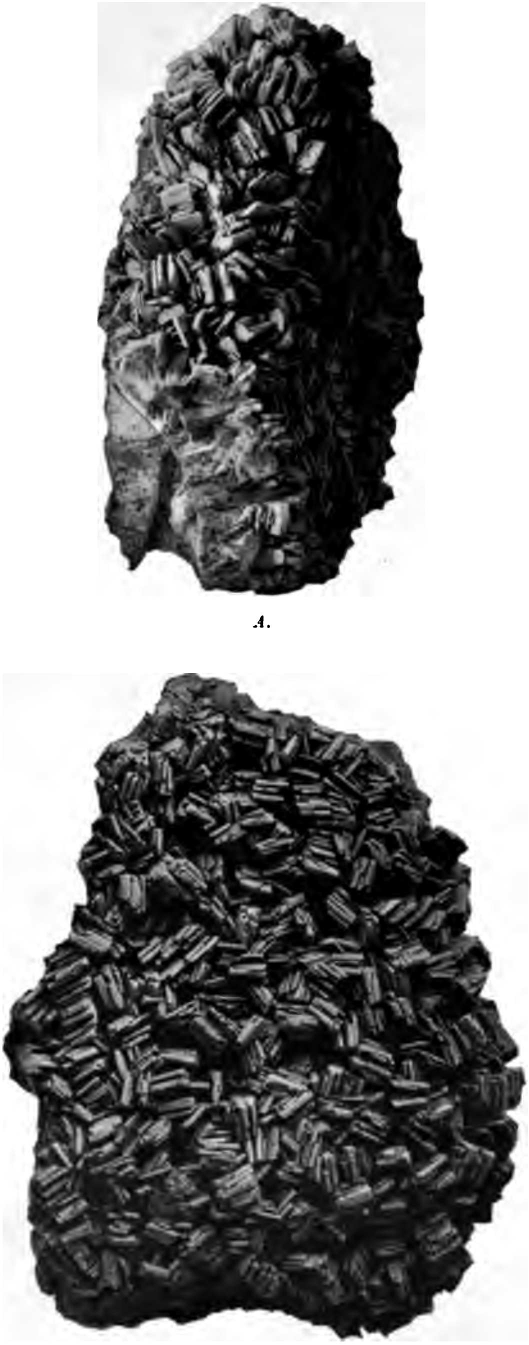
[2] Finlayson, A. M., The scheelite of Otago: New Zealand Inst. Trans. and Proc., vol. 40, p. 112, 1908.

[3] Damour, A., Sur le wolfram tantalifère du département de la Haute-Vienne: Soc. géol. France Bull., 2d ser., vol. 5, p. 108, 1848.



CRYSTALLIZED FERBERITE WITH ELONGATED RHOMBIC CRYSTAL FACES.

From the Nugget mine, Gilpin County, Colo. Coated with ammonium chloride. Natural size.



CRYSTALLIZED FERBERITE WITH ELONGATED RHOMBIC CRYSTAL FACES.

From the Nugget mine, Gilpin County, Colo. Coated with ammonium chloride. Natural size.
A, Edge view. *B*, Side view.

The analyses have all been recalculated in order to bring them to a common basis on which they can properly be compared.

To do this it has been assumed that the theoretically pure members of the wolframite series contain only the hübnerite molecule, $MnWO_4$; the ferberite molecule, $FeWO_4$; or a combination of the two molecules. All analyses have been reduced to these simple forms.

As scheelite, the calcium tungstate, $CaWO_4$, almost universally accompanies the wolframites, the lime indicated in the analyses has been considered to be a component of scheelite unless data given with the analysis showed it to belong to some other mineral, such as luorite. As the CaO is an impurity, it has therefore ordinarily been satisfied with WO_3 and then discarded with all items other than FeO, MnO, and WO_3. Of course, this scheme probably leads to error in certain of the analyses, as the lime in some may be derived from other sources than scheelite, but these sources can not all be known, and as a general rule the process just described seems warranted. As applied to the Boulder field in particular there can be little objection, as lime-bearing minerals other than scheelite are uncommon. Calciferous feldspars seem to occur in very few places, calcite is rare, and no other lime minerals have been noted in the veins.

The analyses have been arranged in a series of decreasing $MnWO_4$ and increasing $FeWO_4$ content, so that the series begins with the hübnerites and ends with the ferberites. This has determined the order of calculation, for the natural procedure has been to satisfy first the MnO with WO_3 and then to combine the remaining WO_3 with so much of the FeO as it would take up. Arbitrary or casual reasons are not the only bases for this mode of calculation, however, for manganese is much less common as an impurity in wolframites than is iron.

The quantity of $MnWO_4$ and $FeWO_4$ obtained as a result of the operations has then been treated as the theoretically pure wolframite present in the substance analyzed, all other substances present being considered as impurities. From the theoretical wolframite as a basis have been computed the percentages of WO_3, FeO, MnO, $FeWO_4$, and $MnWO_4$ of which it is composed.

In making the calculations the following atomic values and molecular ratios have been used:

Atomic weight.		Molecular ratio.	
Calcium	40	$\frac{WO_3}{CaO}=\frac{232}{56}$	4.14
Iron	56	$\frac{WO_3}{FeO}=\frac{232}{72}$	3.22
Manganese	55	$\frac{WO_3}{MnO}=\frac{232}{71}$	3.27
Oxygen	16		
Tungsten	184		

The values of the atomic weights are used only to the nearest integer and the ratios to the second decimal. These values are as exact as are warranted by the errors due to the uncertainty of the constituent minerals of the analyzed material and to the faults of analysis.

As an example of the process of calculation, analysis 37 may be taken:

Analysis of wolframite from Hill City, S. Dak.

Tungsten trioxide (WO_3)	71.0
Ferrous oxide (FeO)	14.3
Manganous oxide (MnO)	10.2
Lime (CaO)	0.7
Silica (SiO_2)	2.9
Magnesia (MgO)	None.
Water (H_2O)	0.3
	99.4

$$\overset{\text{CaO}}{0.7} \times \overset{\frac{\text{WO}_3}{\text{CaO}}}{4.14} = \overset{\text{WO}_3}{2.9}$$

$$\overset{\text{CaO}}{0.7} + \overset{\text{WO}_3}{2.9} = \overset{\text{CaWO}_4}{3.6}$$

$$\overset{\text{MnO}}{10.2} \times \overset{\frac{\text{WO}_3}{\text{MnO}}}{3.27} = \overset{\text{WO}_3}{33.4}$$

$$\overset{\text{MnO}}{10.2} + \overset{\text{WO}_3}{33.4} = \overset{\text{MnWO}_4}{43.6}$$

WO_3 required to satisfy the CaO and MnO	36.3
WO_3 in analysis	71.0
Less quantity for CaO and MnO	36.3
WO_3 to be satisfied by FeO	34.7

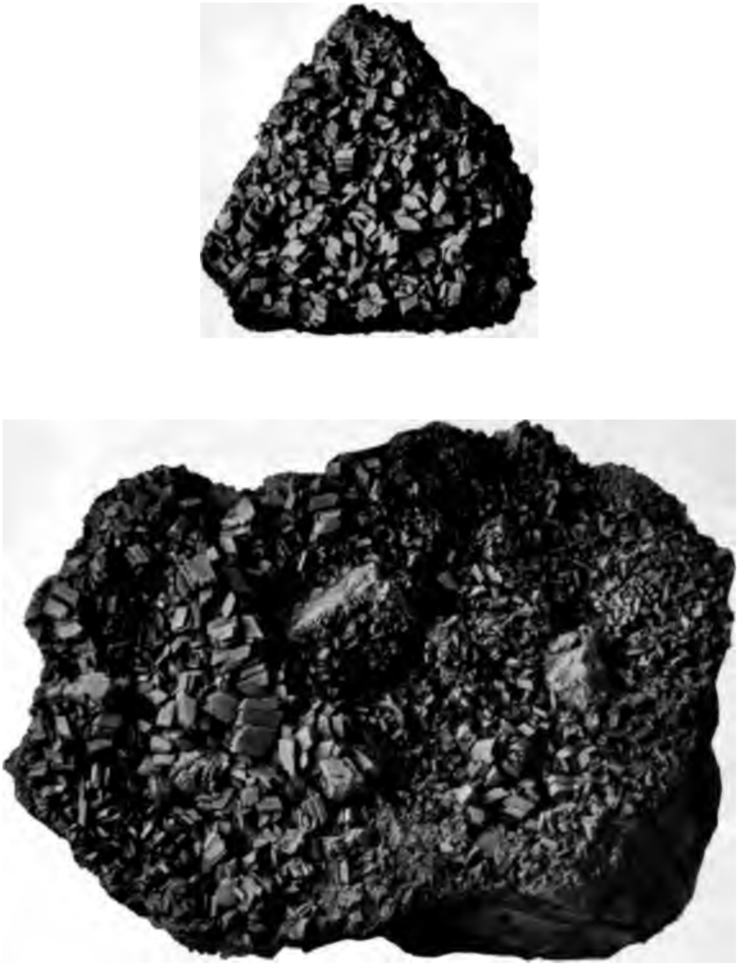
$$\overset{\text{WO}_3}{34.7} \div \overset{\frac{\text{WO}_3}{\text{FeO}}}{3.22} = \overset{\text{FeO required to satisfy remainder of WO}_3.}{10.8}$$

$$\overset{\text{WO}_3}{34.7} + \overset{\text{FeO}}{10.8} = \overset{\text{FeWO}_4}{45.5}$$

FeO in analysis	14.3
FeO required	10.8
Excess of FeO	3.5

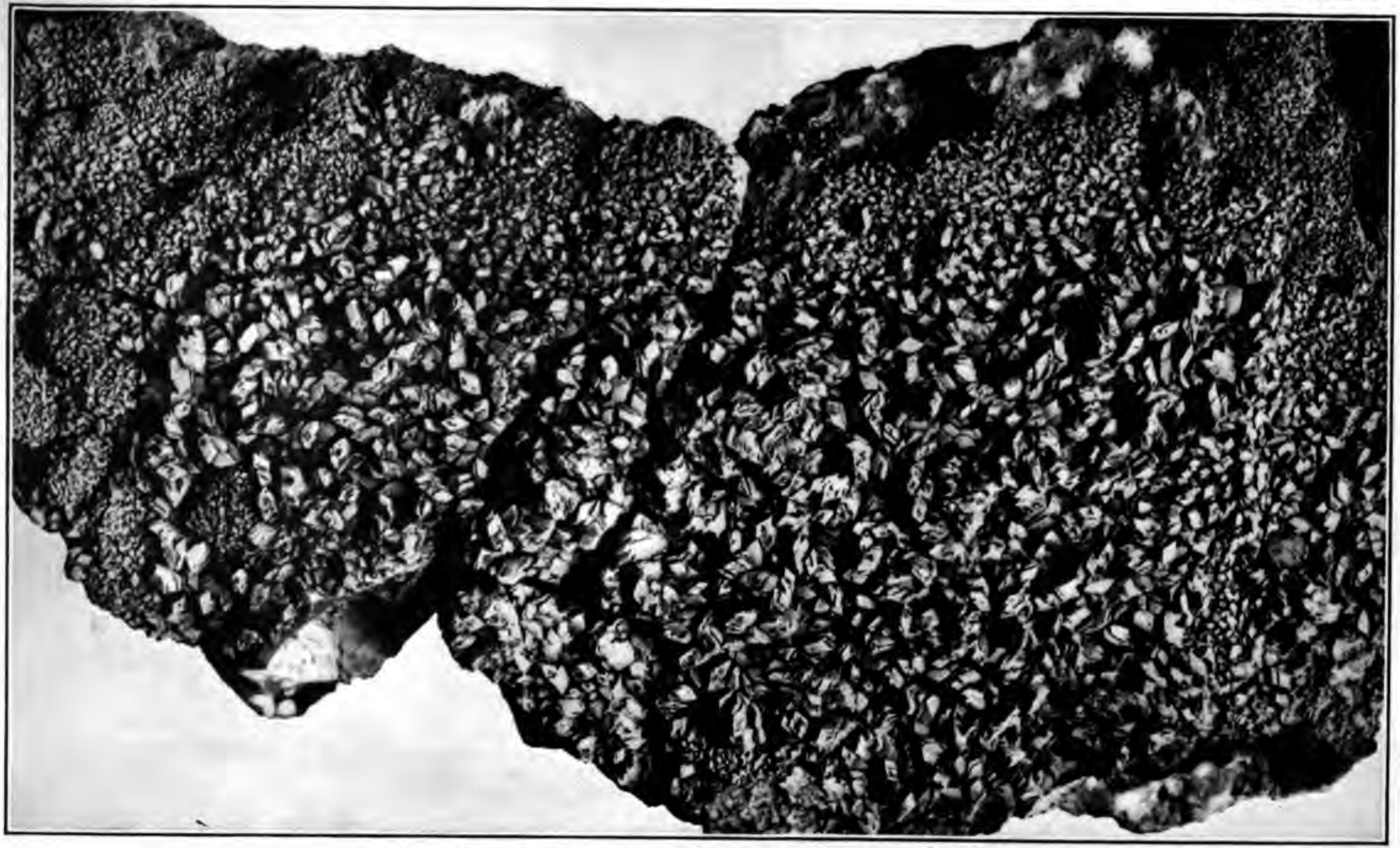
Adding the $MnWO_4$ and $FeWO_4$,

Hübnerite ($MnWO_4$)	43.6
Ferberite ($FeWO_4$)	45.5
Theoretical wolframite in the material analyzed	89.1



FERBERITE WITH RHOMBIC CRYSTAL FACES.

From the Nugget mine, Gilpin County, Colo. Coated with ammonium chloride. Natural size.



VERY FINE SPECIMEN OF FERBERITE WITH RHOMBIC CRYSTAL FACES

Recalculating to percentages of the theoretical wolframite and then breaking up into oxides,

Hübnerite ($MnWO_4$)	48.9 = 11.5 MnO + 37.4 WO_3
Ferberite ($FeWO_4$)	51.1 = 12.1 FeO + 39.0 WO_3
Total WO_3 in theoretical wolframite	76.4

The presence of water (0.3) in the analysis probably indicates that a part of the apparent excess of FeO (3.5) is limonite. The 0.3 per cent of water will combine with 1.6 per cent of FeO to form 2.1 per cent of limonite, considered as $2Fe_2O_3.3H_2O$. This still leaves an excess of 1.9 per cent FeO.

Summarizing, the calculation shows the wolframite to have a composition of—

WO_3	76.4	or	$FeWO_4$	51.1
FeO	12.1		$MnWO_4$	48.9
MnO	11.5			

With which is associated in the mass scheelite, $CaWO_4$, 3.6; excess FeO, 1.9; limonite, 2.1.

Analyses of minerals of

No.	Locality.	Original analysis.							
		WO_3.	FeO.	MnO.	CaO.	SiO_2.	MgO.	Other substances.	Total
	HÜBNERITE.								
1	Philipsburg, Mont.	74.82	0.06	25.00	......	......	......	......	99.88
2	Ouray County, Colo.	75.58	.24	23.40	0.13	0.62	......	Cb_2O_5?, 0.05	100.02
3	Emerald, Nova Scotia.	74.28	.47	22.73	.02	1.33	0.86	MoO_3, trace	99.69
4	White Oaks, N. Mex.	75.45	.55	23.31	.32	.48	None.	$(Cb,Ta)_2O_5$?	100.51
5	Nye County, Nev.	74.88	.56	23.87	.14	......	.08	CuO, 0.08	99.61
6	Morococha, Peru.	74.12	1.42	23.21	......	......	......	......	......
7	Silverton, Colo.	70.21	2.03	21.72	.37	4.91	......	Al_2O_3, 0.56	99.80
8	Schlaggenwalde, Bohemia.	71.50	5.40	23.10	......	......	......	......	100.00
9	Bayevka, Russia.	74.32	2.11	20.90	1.30	.28	......	......	98.91
10	North Star mine, Colo.	74.75	2.91	21.93	.11	......	Trace.	......	99.70
11	Lawrence County, S. Dak.	75.12	3.01	20.54	1.04	......	......	......	99.71
12	Cement Creek, Colo.	76.63	1.61	21.78	.09	......	Trace.	......	100.11
13	Patterson Creek, Idaho.	75.94	2.38	21.57	......	......	......	S, 0.01	99.90
14	Sunday Gulch, S. Dak.	74.46	3.29	19.90	1.05	.42	......	Ignition, 0.75	99.87
15	Dragoon Mountains, Ariz.	75.36	2.66	19.50	......	1.70	......	Undet., 0.78	......
16	Bonito Mountain, N. Mex.	76.33	3.82	19.72	.13	......	Trace.	......	100.00
17	Oroville, Wash.	76.50	4.40	18.50	.20	.70	None.	......	100.30
18	Bayevka, Russia.	76.61	4.64	18.59	.17	......	.20	......	100.21

1. Hübnerite from Philipsburg, Mont. Analysis by A. H. Low quoted from Richard Pearce by Hillebrand, W. F., Miscellaneous mineral notes; Contributions to the mineralogy of the Rocky Mountains: U. S. Geol. Survey Bull. 20, p. 96, 1885.

2. Hübnerite from the Royal Albert vein, Uncompahgre district, Ouray County, Colo. Hillebrand, W. F., Miscellaneous mineral notes; Contributions to the mineralogy of the Rocky Mountains: U. S. Geol. Survey Bull. 20, p. 96, 1885.

3. Hübnerite from Emerald, Nova Scotia. Johnston, R. A. A., Hübnerite: Canada Geol. Survey Ann. Rept., new ser., vol. 11, p. 10R, 1898.

4. Hübnerite from the South Homestake mine, White Oaks, N. Mex. Analysis by J. G. Dinwiddie. Besides the items given the analysis showed H_2O at 110° C., none; H_2O above 110° C., 0.40. This hübnerite is to the unaided eye as black as the ferberite of the Boulder field, but in thin section it is translucent brown and olive-green. The streak is olive-green. Microscopic examination showed no scheelite but much fluorite, so that the calcium has been considered as derived from that mineral. See also analysis 16.

5. Hübnerite from Riotte's original locality, Ellsworth, Mammoth district, Nye County, Nev. Genth, F. A., Contributions to mineralogy, No. 52; with crystallographic notes by S. L. Penfield: Am. Jour. Sci., 3d ser., vol. 43, p. 187, 1892.

6. Hübnerite from Morococha, Peru. Analysis by Pflücker quoted by Domeyko, Ignacio, Mineralojía, vol. 2, p. 92, 1897.

7. Hübnerite from the Natalie mine, Silverton, Colo. Ekeley, J. B., Some Colorado tungsten ores: Min. World, vol. 30, p. 280, 1909.

8. Hübnerite from Schlaggenwalde, Bohemia. Rammelsberg, C. F., Handbuch der Mineralchemie, p. 309, 1860. Fine red brown needles, with fluorspar and apatite.

9. Average of two analyses of hübnerite from Bayevka, Ural Mountains, Russia. Koulibin, Von N. v., Manganhaltiger Wolfram aus der Grube Bajewsk am Ural: Russ.-k. mineral. Gesell. St. Petersburg Verh., vol. 3, 2d ser., p. 3, 1868.

10. Hübnerite from the North Star mine, Silverton, Colo. Genth, F. A., Contributions to mineralogy, No. 52; with crystallographic notes by S. L. Penfield: Am. Jour. Sci., 3d ser., vol. 43, p. 186, 1892.

the wolframite series.

No.	Recalculated analysis.								Specific gravity.
	WO_3.	FeO.	MnO.	$FeWO_4$.	$MnWO_4$.	Excess FeO.	Excess MnO.	$CaWO_4$.	
1	76.6	....	23.4	....	100.0	0.1	2.1	....	....
2	76.6	....	23.4	....	100.0	.2	.5	0.7	7.177
3	76.6	....	23.4	....	100.0	.5	....	.1	....
4	76.6	....	23.4	....	100.0	.6	.2	....	....
5	76.6	....	23.4	....	100.0	.6	1.2	.7	....
6	76.6	....	23.4	....	100.0	1.4	.5	....	....
7	76.6	....	23.4	....	100.0	2.0	.7	1.9	....
8	76.6	....	23.4	....	100.0	5.4	1.2	....	6.45
9	76.6	0.2	23.2	0.8	99.2	1.9	....	6.7	7.357
10	76.6	.8	22.6	3.2	96.8	2.3	....	.6	6.713
11	76.6	1.4	22.0	6.0	94.0	1.2	....	5.4	....
12	76.6	1.6	21.8	6.7	93.3	.1	....	.5	6.891
13	76.6	1.6	21.8	6.9	93.1	.8	....	....	....
14	76.6	1.7	21.7	7.2	92.8	1.7	....	4.4	....
15	76.5	2.8	20.7	11.6	88.4	.1	....	4.1	....
16	76.6	3.5	19.9	14.9	85.1	.3	....	.7	7.163
							Excess WO_3.		
17	76.6	4.5	18.9	19.1	80.9	....	1.7	1.0	7.20
18	76.5	4.7	18.8	19.8	80.2	....	.1	1.0	7.267

11. Hübnerite from the Comstock mine, Lawrence County, S. Dak. Headden, W. P., Mineralogical notes: Colorado Sci. Soc. Proc., vol. 8, p. 175, 1906. "A black mineral fairly well crystallized."

12. Hübnerite from Cement Creek, Silverton, Colo. Genth, F. A., Contributions to mineralogy, No. 52; with crystallographic notes by S. L. Penfield: Am. Jour. Sci., 3d ser., vol. 43, p. 186, 1892.

13. Hübnerite from the Idaho Tungsten Co.'s property in the Blue Wing district, on Patterson Creek, Lemhi County, Idaho. An unpublished analysis by J. E. Talmadge, communicated by J. G. Lind. It seems improbable that from these deposits a specimen could be selected, the analysis of which would show neither SiO_2 nor CaO, but this is of course surmise. In the analysis given, were the ordinary error of high MnO made, it might account for the good summation, were other elements undetermined. On the other hand, manganese oxides occur in the vein in some quantity (see Umpleby, J. B., Geology and ore deposits of Lemhi County, Idaho: U. S. Geol. Survey Bull. 528, pp. 3, etc., 1913), and it may well be that they are present in interstices of the hübnerite, part of which is so dark as to suggest the inclusion of either manganese or iron oxides.

14. Hübnerite from Sunday Gulch, near Hill City, S. Dak. Headden, W. P., Mineralogical notes: Colorado Sci. Soc. Proc., vol. 8, p. 176, 1906. "Granular, almost entirely free from admixed gangue" (p. 175).

15. Hübnerite from Dragoon Mountains, Ariz. Guild, F. N., The mineralogy of Arizona, p. 92, 1910.

16. Hübnerite from Bonito Mountain, near White Oaks, N. Mex. Genth, F. A., Contributions to mineralogy, No. 52; with crystallographic notes by S. L. Penfield: Am. Jour. Sci., 3d ser., vol. 43, p. 187, 1892.

17. Hübnerite from Oroville, Wash. R. C. Wells, of the U. S. Geol. Survey, analyst. SiO_2 includes any other insolubles. Ta, Cb, Sn, Mo, and rare earths are not present in appreciable quantities.

18. Average of two analyses of hübnerite from Bayevka, Ural Mountains. Beck, W., and Teich, N., Ueber Wolfram und Scheelit aus Fundörten Russlands: Russ.-k. mineral. Gesell. St. Petersburg Verh., 2d ser., vol. 4, pp. 315–316, 1869.

Analyses of minerals of

No.	Locality.	Original analysis.							
		WO_3.	FeO.	MnO.	CaO.	SiO_2.	MgO.	Other substances.	Total.
	WOLFRAMITE.								
19	Whetstone Mountains, Ariz.	74.20	5.15	18.09	......	1.95	......	......	99.39
20	Zinnwald, Germany	76.20	5.60	17.94	......	......	......	......	99.74
21	Zinnwald, Bohemia	76.50	10.30	12.20	1.10	......	Trace.	SnO_2, trace	100.10
22	Zinnwald (Germany?)	73.60	11.20	15.75	......	......	......	......	100.55
23	Lake Couchiching, Ontario	73.45	9.05	15.35	......	.20	......	Cb_2O_5?, 1.95	100.00
24	Zinnwald, Germany	75.62	9.55	14.85	......	......	......	......	100.02
25	Altenberg, Germany	75.44	9.64	14.90	......	......	......	......	99.98
26	Zinnwald, Germany	76.01	9.81	13.90	1.19	......	......	......	100.91
27	Freiberg, Germany	75.84	9.20	14.56	......	......	......	......	99.60
28	Schlaggenwalde, Bohemia	75.68	9.56	14.30	......	......	......	......	99.54
29	Zinnwald (Germany?)	75.99	9.62	13.96	.48	......	......	......	100.05
30	Zinnwald, Germany	76.34	9.61	14.21	......	......	......	......	100.16
31	....do	75.62	8.73	12.17	2.27	......	......	TiO_2 1.89 H_2O, 0.31	100.99
32	Tenasserim, Burma	72.80	11.44	12.08	1.18	2.36	......	Loss, 0.14	100.00
33	Cornwall, England	74.84	10.81	12.55	.80	.30	.12	$(Ta,Cb)_2O_5$, 0.26	100.38
34	Lost River, Alaska	74.90	10.60	12.80	.30	.90	Trace?	PbO, trace?	100.10
35	Vilate, France	73.93	12.97	11.60	......	......	......	Ta_2O_5, 1.03	99.53
36	Sudzukoya, Japan	71.90	15.29	10.64	......	1.02	......	Undet., 1.15	......
37	Hill City, S. Dak	71.00	14.30	10.20	.70	2.90	None.	H_2O, 0.30	99.40
38	Sierra Cordoba, Argentina	74.86	13.45	11.02	......	......	......	Cb_2O_5, 1.22	100.55

19. Wolframite from the Whetstone Mountains, 12 miles south of Benson, Ariz. Analysis by J. M. Ruthrauff quoted by Guild, F. N., The mineralogy of Arizona, p. 94, 1910.

20. Wolframite from Zinnwald, Germany. Bernoulli, F. A., Ueber Wolfram und einige seiner Verbindungen: Poggendorf's Annalen, 4th ser., vol. 21, p. 604, 1860.

21. Wolframite from Zinnwald, Bohemia. Helmhacker, R., Wolfram ore: Eng. and Min. Jour., vol. 62, p. 154, 1896.

22. Wolframite from Zinnwald (Germany?). Richardson, T., Analysis of wolfram: Thomson's Records of general science, vol. 1, p. 451, 1835.

23. Wolframite from Lake Couchiching, Ontario. Hunt, T. S., Analysis of Canadian wolfram: Canadian Jour., new ser., vol. 5, p. 303, 1860.

24. Wolframite from Zinnwald, Germany. Kerndt, T., Ueber die Krystallform und chemische Zusammensetzung der natürlichen und künstlichen Verbindungen des Wolframmetalles: Jour. prakt. Chemie, vol. 42, p. 97, 1847.

25. Wolframite from Altenberg, Germany. Kerndt, T., Ueber die Krystallform und chemische Zusammensetzung der natürlichen und künstlichen Verbindungen des Wolframmetalles: Jour. prakt. Chemie, vol. 42, p. 110, 1847.

26. Wolframite from Zinnwald, Germany. Schneider, R., Ueber die chemische Constitution des Wolframminerals: Jour. prakt. Chemie, vol. 49, p. 332, 1850.

27. Wolframite from Neubeschert-Glück, Freiberg, Germany. Kerndt, T., Ueber die Krystallform und chemische Zusammensetzung der natürlichen und künstlichen Verbindungen des Wolframmetalles: Jour. prakt. Chemie, vol. 42, p. 102, 1847.

28. Wolframite from Schlaggenwalde, Bohemia. Kerndt, T., Ueber die Krystallform und chemische Zusammensetzung der natürlichen und künstlichen Verbindungen des Wolframmetalles: Jour. prakt. Chemie, vol. 42, p. 109, 1847.

29. Wolframite from Zinnwald, Germany (?). Ebelmen, J. J., Note sur la composition du wolfram: Annales des mines, 4th ser., vol. 4, p. 407, 1843.

30. Wolframite from Zinnwald, Germany. Kerndt, T., Ueber die Krystallform und chemische Zusammensetzung der natürlichen und künstlichen Verbindungen des Wolframmetalles: Jour. prakt. Chemie, vol. 42, p. 96, 1847.

the wolframite series—Continued.

No.	Recalculated analysis.								Specific gravity.
	WO^3.	FeO.	MnO.	$FeWO^4$.	$MnWO^4$.	Excess FeO.	Excess WO_3.	$CaWO^4$.	
19	76.5	4.8	18.7	20.3	79.7	0.5	....	....	....
20	76.6	5.4	18.0	23.0	77.0	.2	....	....	....
21	76.5	6.4	17.1	27.1	72.9	4.6	....	5.7	....
22	76.5	7.1	16.4	30.1	69.9	4.3	....	....	7.017
23	76.5	7.5	16.0	31.5	68.5	1.9	....	....	....
24	76.5	8.5	15.0	35.8	64.2	1.2	....	....	7.230
25	76.5	8.6	14.9	36.3	63.7	1.2	....	....	7.198
26	76.5	8.7	14.8	36.6	63.4	1.7	....	6.1	....
27	76.5	8.7	14.8	37.3	62.7	.4	....	....	7.229
28	76.5	9.1	14.4	38.3	61.7	.6	....	....	7.535
29	76.5	9.1	14.4	38.4	61.6	.8	....	2.5	....
30	76.5	9.3	14.2	39.2	60.8	.3	....	....	....
31	76.5	9.4	14.1	39.8	60.2	.5	....	11.7	....
32	76.5	9.9	13.6	41.9	58.1	2.6	....	6.1	....
33	76.5	10.1	13.4	42.7	57.3	1.9	....	4.1	7.272
34	76.4	10.3	13.3	43.3	56.7	.7	....	1.5	7.000
35	76.4	11.6	12.0	48.8	51.2	1.8	....	....	....
36	76.4	12.1	11.5	50.9	49.1	4.0	....	....	....
37	76.4	12.1	11.5	51.1	48.9	1.9	(a)	3.6	....
38	76.4	12.3	11.3	51.9	48.1	1.4	....	....	....

[a] Limonite 2.1 per cent.

31. Wolframite from Zinnwald, Germany. Weidinger, G., Analyse eines Wolframkrystalls aus den Gruben bei sächsisch Zinnwald an der böhmisch-sächsischen Grenze: Zeitschr. Pharm., vol. 7, p. 73, 1855.

32. Wolframite presumably from the property of the Mount Pima Mining Co. (Ltd.), Tenasserim, Lower Burma. A published analysis by O. Burger furnished through the courtesy of Radcliff & Co., Rangoon, Burma.

33. Wolframite from Cornwall, England. The exact locality of origin is unknown. Analysis by Edgar T. Wherry on specimen No. 80179 in the United States National Museum. The analysis, which will appear in the Proceedings of the Museum, showed, besides the items given: Fe_2O_3, 0.70, which was calculated to its equivalent of FeO and added to that item. The wolframite is black and opaque and occurs in large crystals with pyrite and chalcopyrite. A section showed a later deposition of very thin bands of scheelite and wolframite in cracks of the crystals, so that the CaO evidently should be calculated into scheelite.

34. Wolframite from Lost River, Alaska. R. C. Wells, of the U. S. Geol. Survey, analyst. No Ta, Cb, Mo, or rare earths present.

35. Wolframite from between Vilate and Chanteloube, France. Damour, A., Sur le wolfram tantalifère du département de la Haute-Vienne: Soc. géol. France Bull., 2d ser., vol. 5, p. 108, 1848.

36. Wolframite from Takatori mine, Takatori Mountain, near Sudzukoya, Higashi-Ibaraki County, State of Hitachi, Japan. The mine is 12 miles northwest of Mito and 14 miles northeast of Kasama. Analysis by S. Katsuno, personal communication, Nov. 30, 1912.

37. Wolframite from Black Metal claims, Hill City, S. Dak. R. C. Wells, of the U. S. Geol. Survey, analyst. Any Al_2O_3 present is included with the FeO.

38. Wolframite from the southern end of the Sierra Cordoba, Argentina. Bodenbender, G., Die Wolfram-Minen der Sierra von Córdoba in der Argentinischen Republik: Zeitschr. prakt. Geologie, Nov., 1894, p. 409.

Analyses of minerals of

No.	Locality.	Original analysis.							
		WO_3.	FeO.	MnO.	CaO.	SiO_2.	MgO.	Other substances.	Total.
	WOLFRAMITE—continued.								
39	Lead, S. Dak.	61.70	9.18	8.21	0.93	12.87	Trace.		99.64
40	Montebelleux, France	76.21	12.87	10.52		.15			99.75
41	Sadisdorf, Germany	70.38	13.88	9.52	2.16				100.70
42	.....do	73.47	15.13	9.81	.54				100.05
43	Tavoy, Burma	74.78	13.80	9.36	Trace.	.30	Trace.	Cb_2O_5, 0.20	100.12
44	Wheal Gorland, Cornwall	51.00	20.20	6.07		1.83		As, 3.82	
45	Northwest Spain	64.13	10.88	6.42	1.21	7.71	3.16	SnO_2, 0.68	99.89
46	Quebrada de la Viuda, Argentina.	75.07	15.61	8.24	.52		.31	Cb_2O_5, 1.12	100.87
47	Miramichi River, New Brunswick.	74.43	16.90	8.37					99.70
48	Altai, Siberia	75.56	16.22	8.42					100.20
49	Ward, Colo	71.27	20.01	7.15	1.58				100.01
50	Felsobanya, Hungary	76.14	15.67	8.34					100.15
51	Perilhao, Portugal	73.46	16.90	6.97		2.69			100.02
52	Wheal Gorland, Cornwall	57.18	15.87	5.30		6.83		As, 2.39	

39. Wolframite from Two Strike mine, Yellow Creek, Lead, S. Dak. W. F. Hillebrand, analyst. Irving, J. D., Economic resources of the northern Black Hills: U. S, Geol. Survey Prof. Paper 26, p. 167, 1904. Besides the items noted, the analysis showed: Fe_2O_3, 3.85; Al_2O_3, 0.52; SrO, 0.02; BaO, 0.04; $K_2O+Na_2O+Li_2O$, 0.08; H_2O, below 105° C., 0.20; H_2O above 105° C., 0.87; As_2O_5, 1.25; P_2O_5, 0.12; traces of V_2O_5 and S or SO_3. Extremely minute traces of Zn, Cu, Sb, and Sn were also found. Assays gave: Gold 0.05 ounce and silver 0.25 ounce to the ton of 2,000 pounds. The P_2O_5 was probably combined with CaO as apatite, and 0.18 has therefore been deducted from the CaO before combining it with WO_3 for scheelite. The FeO is not sufficient, as indicated by the analysis, to combine with the WO_3, and 0.6 must be taken from the Fe_2O_3 to supply the deficiency. A partial analysis of a specimen from the Harrison mine, near Lead, is given, as follows: SiO_2, 9.60; WO_3, 61.70; Fe_2O_3 and FeO, 12.67, MnO, 7.21; CaO, 5.39. Recalculated: WO_3, 76.5; FeO, 9.5; MnO, 14.0; $FeWO_4$; 40.2; $MnWO_4$, 59.8; $CaWO_4$, 39.4. In this analysis the CaO (5.39) is high, and no determination of P_2O_5 is indicated. There is no corresponding increase in the WO_3 and the relation of the FeO: MnO is so much different as to indicate that part of the lime probably belongs in apatite. Specimens of ore collected by the present writer from this general locality and examined microscopically show apatite in small quantity. As given, the analysis falls between Nos. 31 and 32.

40. Wolframite from Montebelleux, Brittany, France. Bourion, F., Sur un mode général de préparation des chlorures anhydres et ses applications à l'analyse chimique: Annales chim. phys., 8th ser., vol. 21, p. 103, 1910.

41. Wolframite from the Kupfergrube, Sadisdorf, Germany. Winter, H., Ueber Vorkommen und Reindarstellung des Scandiums: Inaugural-Dissertation, Friedrich-Wilhelms-Universität zu Berlin, p. 23, 1911. Besides the items mentioned, the analysis shows PO_4, 2.23; MoO_3, trace; earth acids (TaO_2, TiO_2), 2.07; PbO, 0.46; Sc, 0.2. It is stated that calcium phosphate was present in the gangue, and the CaO has therefore been combined with the PO_4, which it is hardly sufficient to satisfy.

42. Wolframite from the Kupfergrube, Sadisdorf, Germany. Winter, H., Ueber Vorkommen und Reindarstellung des Scandiums: Inaugural-Dissertation, Friedrich-Wilhelms-Universität zu Berlin, p. 22, 1911. The analysis also showed: TiO_2 and TaO_2, 0.63; PbO and SnO_2, 0.47; Sc, 0.2.

43. Wolframite from the Tavoy district, Lower Burma. Analysis by C. S. Fawcitt. Bleeck, A. W. G., On some occurrences of wolframite lodes and deposits in the Tavoy District of Lower Burma. India Geol. Survey Records, vol. 43, pt. 1, pp. 67–68, 1913.

the wolframite series—Continued.

No.	Recalculated analysis.								Specific gravity.
	WO_3.	FeO.	MnO.	$FeWO_4$.	$MnWO_4$.	Excess FeO.	Excess WO_3.	$CaWO_4$.	
39	76.4	12.8	10.8	54.1	45.9	....	....	4.0	....
40	76.4	13.0	10.6	54.8	45.2	....	0.2	....	....
41	76.4	13.2	10.4	55.8	44.2	1.7	....	....	....
42	76.4	13.4	10.2	56.4	43.6	3.0	....	2.8	....
43	76.4	14.0	9.6	59.2	40.8	.1	....	....	....
44	76.4	14.5	9.1	61.0	39.0	(?)	....	....	....
45	76.4	14.9	8.7	62.8	37.2	....	3.1	6.2	....
46	76.4	15.0	8.6	63.2	36.8	1.3	....	2.7	....
47	76.4	15.0	8.6	63.3	36.7	2.3	....	....	....
48	76.4	15.1	8.5	63.6	36.4	1.3	....	....	6.968
49	76.4	15.1	8.5	63.8	36.2	7.2	....	8.1	....
50	76.4	15.2	8.4	64.3	35.7	.5	....	....	7.458
51	76.4	16.3	7.3	69.0	31.0	1.2	....	....	....
52	76.4	16.6	7.0	70.0	30.0	.2	....	....	....

Besides the items noted in the table, the analysis shows Al_2O_3, 0.81; Bi_2O_3, 0.14; SnO_2, trace; MoO_3, 0.51; H_2O, 0.22.

44. Ore from Wheal Gorland, Cornwall. Analysis by B. Kitto, communicated by Mr. R. Woodward, managing director of Edgar Allen & Co. (Ltd.), Sheffield, England. The analysis also shows: Pb, 0.10; Mg, trace; Bi, 0.15; P, trace; CaF_2, 4.06; Cu, 0.88; S, 2.02; Al_2O_3, 1.77; SnO_2, 8.64; O, by difference, 3.96. Cu, Fe, S, and As were combined as nearly as possible to form chalcopyrite and arsenopyrite. Although not made on as pure material as might be wished for the purposes of this paper, the analysis shows approximately the composition of the wolframite.

45. Wolframite from northwest Spain (ore). Steinhart, O. J., Classification, occurrence, identification, and properties of tungsten ores: Mineral Industry, vol. 17, p. 830, 1909. The analysis also shows: Al_2O_3, 5.32; and CrO, 0.38.

46. Wolframite from Quebrada de la Viuda, Department of San Xavier, Argentina. Bodenbender, G., Die Wolfram-Minen der Sierra von Córdoba in der Argentinischen Republik: Zeitschr. prakt. Geologie, Nov., 1894, p. 409. A trace of CaO is present but no MgO.

47. Wolframite from the confluence of the southwest Miramichi and Burnt Hill Brook, New Brunswick. Walker, T. L., Recently discovered wolframite deposits in New Brunswick: Econ. Geology, vol. 6, p. 397, 1911.

48. Wolframite from Kolywanowschen mine, Altai, Siberia. Beck, W., and Teich, N., Ueber Wolfram und Scheelit aus Fundörten Russlands: Russ.-k. mineral. Gesell. St. Petersburg Verh., 2d ser., vol. 4, p. 317, 1869.

49. Wolframite from Ward, Colo. Analysis by J. B. Ekeley. George, R. D., The main tungsten area of Boulder County, Colo.: Colorado Geol. Survey First Rept., p. 43, 1909.

50. Wolframite from Felsobanya, Hungary. Sipöcz, L., Ueber die chemische Zusammensetzung einiger seltener Minerale aus Ungarn: Min. pet. Mitt., new ser., vol. 7, p. 270, 1886.

51. Wolframite from Perilhao, Portugal. Bourion, F., Sur un mode général de préparation des chlorures anhydres et ses applications a l'analyse chimique: Annales chim. et phys., 8th ser., vol. 21, p. 104, 1910.

52. Ore from Wheal Gorland, Cornwall. Analysis by B. Kitto, communicated by Mr. R. Woodward, managing director of Edgar Allen & Co. (Ltd.), Sheffield, England. Fe (12.34) has been calculated as FeO (15.87). The analysis also shows: SnO_2, 2.75; traces of Pb and MgO; CaF_2, 4.37; Cu, 0.45; S, 1.31; Al_2O_3, 4.13; and O, by difference, 2.95.

Analyses of minerals of

No.	Locality.	Original analysis.							
		WO_3.	FeO.	MnO.	CaO.	SiO_2.	MgO.	Other substances.	Total.
	WOLFRAMITE—continued.								
53	Meymac, France	74.75	16.17	6.40	0.40	1.12	0.17	Ta_2O_5, 0.95	99.96
54	do	74.25	15.85	6.51	.80		.04	H_2O, 0.70 Ta_2O_5, 1.16	99.25
55	Oreville, S. Dak	76.00	17.00	6.60	.20	.90	None.		100.70
56	Carrock Fell, England	76.24	16.39	6.05	1.05		.11		99.84
57	Mount Carbine, Queensland	71.2	18.0	6.0		4.0		Bi, 0.1 Cu, 0.2	
58	Gordon Gulch, Colo	60.84	18.36	4.73		16.28		S, 0.20 P, 0.05	
59	Cabarrus County, N. C	75.79	19.80	5.35	.32			SnO_2, trace	101.26
60	Neudorf, Germany	76.21	18.54	5.23	.40		.36		100.74
61	Pioche, Nev	70.73	16.42	4.71	.50	.20	.14	$(Ta,Cb)_2O_5$, 0.82	97.08
62	Irish Creek, Va	74.56	15.19	3.84	4.10		.41	$(Ta,Cb)_2O_5$, etc., 0.96.	100.20
63	Stassberg, Germany	76.57	18.98	4.90	.70		Trace.		101.15
64	Cedar Canyon, Wash	75.73	18.68	4.93		.36		Undet., 0.22	99.92
65	Chanteloube, France	75.82	19.33	4.84					99.99
66	Harzgerode, Germany	75.90	19.25	4.80					99.95
67	Monte Video	76.02	19.21	4.75					99.98

53. Wolframite from Meymac, Correze, France. Carnot, A., Sur quelques minéraux de tungstène de Meymac (Correze): Compt. Rend., vol. 79, p. 638, 1874. Any alumina present is included with the silica.

54. Wolframite from Meymac, Correze, France. Carnot, A., Sur quelques minéraux de tungstène de Meymac (Correze): Compt. Rend., vol. 79, p. 638, 1874.

55. Wolframite from "Wolfram" claim, 3 miles east of Oreville, S. Dak. R. C. Wells, of the U. S. Geol. Survey, analyst. SiO_2 includes any other insolubles. Ta, Cb, Sn, Mo, and rare earths are not present in appreciable quantities.

56. Wolframite from Carrock Fell, England. Finlayson, A. M., The ore-bearing pegmatites of Carrock Fell and the genetic significance of tungsten ores: Geol. Mag., vol. 7, p. 21, 1910.

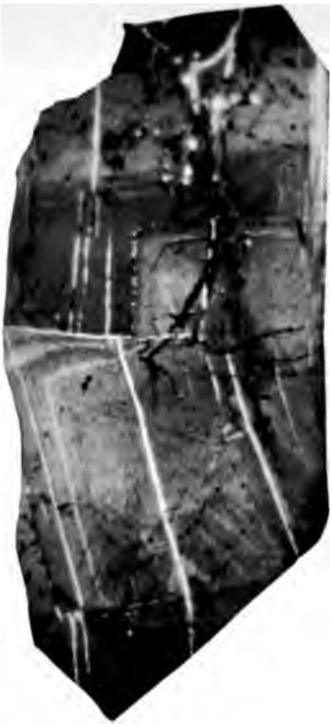
57. Wolframite. Analysis of "typical Mount Carbine [Queensland] wolfram concentrate" by Alex. Cumming. The SiO_2 (4.0) includes "insol., etc." Besides the items in the table there is also "undetermined, 0.5." Quoted by Ball, L. C., Wolfram mines of Mount Carbine. No. 1: Queensland Govt. Min. Jour., vol. 14, p. 70, 1913.

58. Ore from Gordon Gulch, Boulder County, Colo. Greenawalt, W. E., The tungsten deposits of Boulder County, Colo.: Eng. and Min. Jour., vol. 83, p. 951, 1907. The analysis also includes: Gold, trace; silver, 3.1 ounces to the ton. The item given under SiO_2 is given by Greenawalt as "Si."

59. Wolframite from the Flowe mine, Cabarrus County, N. C. Genth, F. A., The minerals of North Carolina: U. S. Geol. Survey Bull. 74, p. 80, 1891.

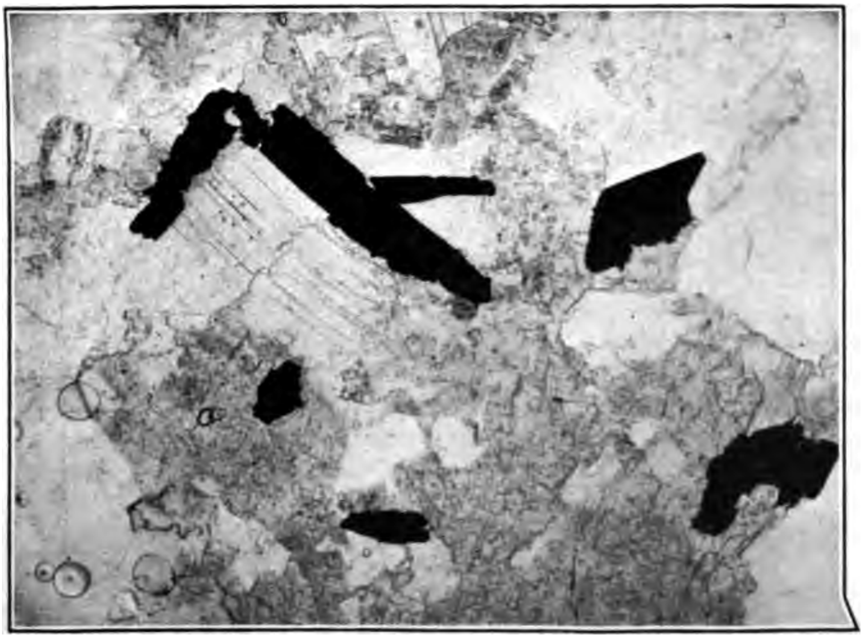
60. Wolframite from Grube Pfaffenberg, Neudorf, Harz Mountains, Germany. Schneider, R., Ueber die chemische Constitution des Wolfram-Minerals: Jour. prakt. Chemie, vol. 49, p. 334, 1850.

61. Black wolframite from Silver Comet mine, 11 miles west of Pioche, Nev. J. G. Dinwiddie, analyst; personal communication. The analysis also showed Fe_2O_3, 2.92; H_2O below 110° C, 0.03; H_2O above 110° C., 0.57. The FeO of the analysis gave an



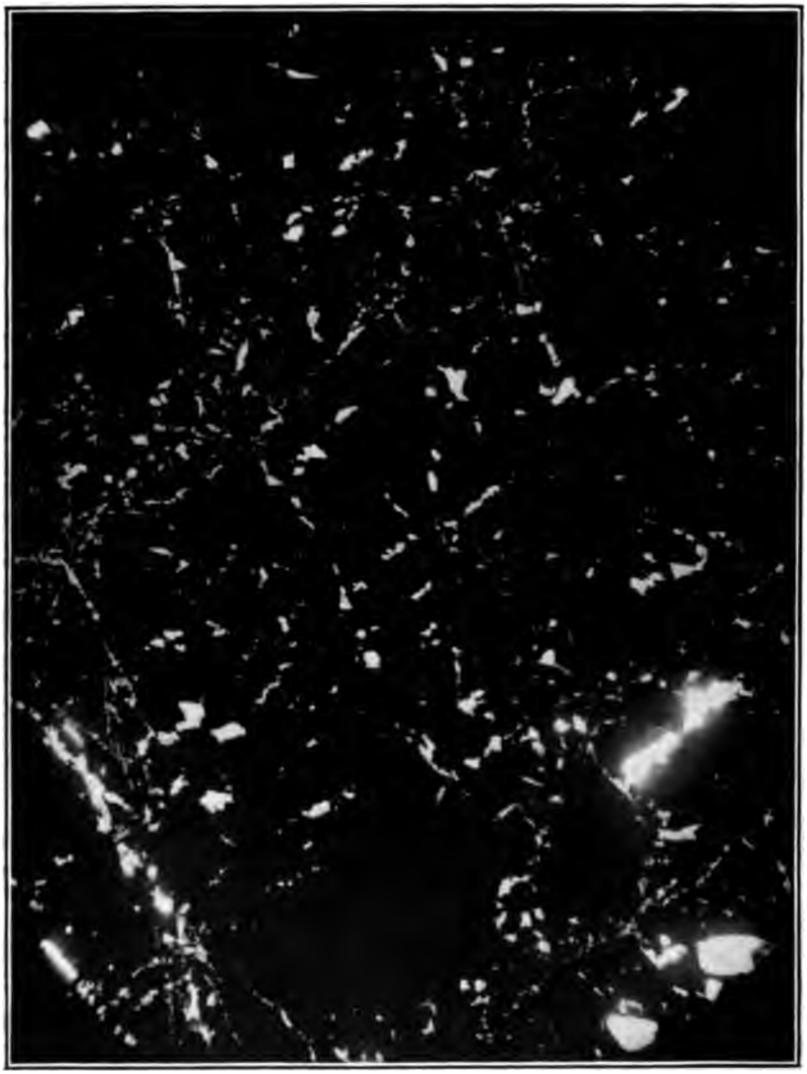
A. HÜBNERITE FROM THE DRAGOON MOUNTAINS, ARIZ.

Section showing zonal structure. × 5.



B. PHOTOMICROGRAPH OF GRANITE FROM WHETSTONE MOUNTAINS, ARIZ.

Showing wolframite (black) with warty protuberances of scheelite. × 90.



WOLFRAMITE FROM IRISH CREEK, VA.

Section showing interstitial scheelite. × 30.

the wolframite series—Continued.

No.	Recalculated analysis.								Specific gravity.
	WO₃.	FeO.	MnO.	FeWO₄.	MnWO₄.	Excess FeO.	Excess WO₃.	CaWO₄.	
53	76.4	16.6	7.0	70.1	29.9	0.4	....	4.1	....
54	76.4	16.9	6.7	71.4	28.6	.1	....	2.1	....
55	76.4	16.9	6.7	71.4	28.6	.4	....	1.0	6.70
56	76.4	17.2	6.4	72.5	27.5	.2	....	5.4	....
57	76.4	17.2	6.4	72.5	27.5	2.0	....	....	....
58	76.4	17.7	5.9	74.6	25.4	4.3	....	....	....
59	76.4	18.1	5.5	76.6	23.4	2.1	....	1.7	7.496
60	76.4	18.3	5.3	77.2	22.8	.6	....	2.1	....
61	76.4	18.3	5.3	77.4	22.6	2.8	....	3.3	....
62	76.3	18.6	5.1	78.3	21.7	1.2	....	21.1	....
63	76.3	18.6	5.1	78.3	21.7	1.1	....	3.6	....
64	76.3	18.7	5.0	78.8	21.2	.2	....	....	....
65	76.3	18.8	4.9	79.2	20.8	.7	....	....	7.51
66	76.3	18.9	4.8	79.4	20.6	.5	....	....	7.228
67	76.3	18.9	4.8	79.6	20.4	.4	....	....	7.513

excess of 0.2 and to this has been added 2.6, the equivalent of the Fe_2O_3 given. In appearance the material is so pure that it is difficult to account for the apparent presence of 3.3 per cent of scheelite ($CaWO_4$). Possibly the "H_2O above 110° C., 0.57," should be CO_2.

62. Wolframite from Cash tin mine, Irish Creek, Rockbridge County, Va. Analysis by J. G. Dinwiddie. The analysis also shows Fe_2O_3, 4.03; FeO, 11.56; H_2O at 110°, 0.12; H_2O above 110°, 0.63; TiO_2, 0.02; Al_2O_3, 0.32; CO_2, 0.5. The Fe_2O_3 has been changed to FeO and added to that item. It is extremely difficult to make accurate determinations of ferric and ferrous iron in the wolframites, owing to the likelihood of part of the iron being oxidized during grinding and difficulties inherent in the chemical determination. The change also makes the analysis foot up better. The scheelite ($CaWO_4$) is very high, (21.1), but specimens of wolframite from the locality show many inclusions of scheelite. (See Pl. XIV.)

63. Wolframite from Neuhaus Stollberg, Stassberg, Harz Mountains, Germany. Analysis by Petzold. Schneider, R., Ueber einen härzer Wolfram: Poggendorf's Annalen, 4th ser., vol. 3, p. 474, 1854.

64. Wolframite from the Germania mine, Cedar Canyon, Stevens County, Wash. R. C. Wells, of the U. S. Geol. Survey, analyst.

65. Wolframite from Chanteloube, Limoges, France. Kerndt, T., Ueber die Krystallform und chemische Zusammensetzung der natürlichen und künstlichen Verbindungen des Wolframmetalles: Jour. prakt. Chemie, vol. 42, p. 105, 1847.

66. Wolframite from Harzgerode, Germany. Kerndt, T., Ueber die Krystallform und chemische Zusammensetzung der natürlichen und künstlichen Verbindungen des Wolframmetalles: Jour. prakt. Chemie, vol. 42, p. 105, 1847.

67. Wolframite from "Monte Video," country not given, Kerndt, T., Ueber die Krystallform und chemische Zusammensetzung der natürlichen und künstlichen Verbindungen des Wolframmetalles: Jour. prakt. Chemie, vol. 42, p. 102, 1847.

Analyses of minerals of

No.	Locality.	Original analysis.							
		WO_3.	FeO.	MnO.	CaO.	SiO_2.	MgO.	Other substances.	Total.
	FERBERITE.								
68	Limoges, France	76.20	19.19	4.48	......	......	0.80	......	100.67
69	Traversella, Italy	75.99	16.29	3.45	4.03	......	......	......	99.76
70	Nagpur, India	51.59	14.50	2.94	......	3.40	......	P, 0.018	72.45
71	Estremadura, Spain	72.93	22.70	4.10	......	......	......	......	99.73
72	Inverell, New South Wales	77.64	18.76	4.12	......	......	......	......	100.52
73	Neudorf, Germany	76.30	20.12	4.12	.38	......	.16	......	101.08
74	Torrington, New South Wales	70.73	18.13	3.64	1.64	......	Trace.	Gangue, 5.55	99.69
75	Gordon Gulch, Colo	61.80	16.36	3.12	.35	15.93	1.71	Al_2O_3, 1.06	100.33
76	Neudorf, Germany	76.28	20.38	3.80	.20	......	.07	......	100.73
77	Beaver Creek, Colo	66.41	24.31	3.25	......	6.00	......	S, 0.02 P, trace	......
78	Cave Creek, Ariz	73.74	18.18	3.37	.24	.72	......	$(Ta,Cb)_2O_5$, 2.20	99.79
79	Sierra Almagrera, Spain	70.11	23.29	3.02	1.75	......	.42	Cb_2O_5, trace	99.90
80	Kootenay Belle mine, British Columbia.	74.90	17.75	2.75	1.52	1.02	2.66	......	100.60
81	Hill City, S. Dak	70.94	17.61	2.71	......	8.70	......	......	99.96
82	Sierra Almagrera, Spain	69.06	25.97	2.17	1.52	......	......	......	98.72
83	Adun-Tschilon, Siberia	75.55	21.31	2.37	.26	......	.51	......	100.00
84	Ivigtut, Greenland	75.19	22.97	1.33	......	......	......	Cb_2O_5, 0.76	100.25
85	Last Chance, Colo	62.30	19.90	.69	.79	14.68	......	Al_2O_3 1.34	99.70

68. Ferberite from Limoges, probably from Puy-les-Vignes. (See Lacroix, A., Minéralogie de la France et de ses colonies, vol. 4, pt. 1, p. 285, footnote, 1910.) Ebelmen, J. J., Note sur la composition du wolfram: Annales des mines, 4th ser., vol. 4, p. 407, 1843.

69. Ferberite from Traversella, Italy. Bernoulli, F. A., Ueber Wolfram und einige seiner Verbindungen: Poggendorf's Annalen, 4th ser., vol. 21, p. 603, 1860.

70. Ferberite from Nagpur district, India. Analysis by Carnegie Steel Co. Quoted by Fermor, L. L., Note on an occurrence of wolfram in the Nagpur district, Central Provinces: India Geol. Survey Records, vol. 36, pt. 4, p. 309, 1908.

71. Ferberite from Estremadura, Spain. Analysis by Truchot quoted by Mennicke, Hans, Die Metallurgie des Wolfram, p. 18, 1911.

72. Ferberite from Inverell, County Gough, New South Wales. Liversidge, A., The minerals of New South Wales, p. 85, 1888.

73. Ferberite from Grube Meiseberg, Neudorf, Harz Mountains, Germany. Schneider, R., Ueber die chemische Constitution des Wolfram-Minerals: Jour. prakt. Chemie, vol. 49, p. 334, 1850.

74. Ferberite from the Bismuth mine, Torrington, New South Wales. Analysis by H. P. White quoted by Carne, J. E., The tungsten mining industry in New South Wales: New South Wales Geol. Survey Min. Res. No. 15, p. 70, 1912.

75. Ferberite from Gordon Gulch, Boulder County, Colo. Analysis quoted as having been made by the Colorado Tungsten Corporation. George, R. D., The main tungsten area of Boulder County, Colo.: Colorado Geol. Survey First Rept., p. 43, 1909.

76. Ferberite from Grube Meiseberg, Neudorf, Germany. Schneider, R., Ueber die chemische Constitution des Wolfram-Minerals: Jour. prakt. Chemie, vol. 49, p. 334, 1850.

77. Ore from Beaver Creek, Boulder County, Colo. Analysis given by Greenawalt, W. E., The tungsten deposits of Boulder County, Colo.: Eng. and Min. Jour., vol. 83, p. 951, 1907. The analysis also gives: Gold, trace; silver, 1.2 ounces to the ton. The item given under SiO_2 is designated in the original as "Si."

78. Ferberite from Cave Creek, Maricopa County, Ariz., U. S. Nat. Mus. catalogue No. 87283. Analysis by Edgar T. Wherry. The mineral is black and opaque. The

the wolframite series—Continued.

No.	Recalculated analysis.								Specific gravity.
	WO₃.	FeO.	MnO.	FeWO₄.	MnWO₄.	Excess FeO.	Excess WO₃.	CaWO₄.	
68	76.4	19.1	4.5	80.8	19.2	0.1	....	....	....
69	76.4	19.2	4.4	81.1	18.9	1.4	....	20.7	....
70	76.4	19.3	4.3	81.5	18.5	1.5	....	....	....
71	76.4	19.3	4.3	81.7	18.3	4.2	....	....	....
72	76.3	19.4	4.3	81.8	18.2	....	3.7	....	....
73	76.3	19.5	4.2	82.1	17.9	1.1	....	2.0	....
74	76.35	19.7	3.95	83.1	16.9	....	....	.6	....
75	76.3	19.8	3.9	83.4	16.6	.8	....	1.8	....
76	76.4	19.8	3.8	83.6	16.4	.8	....	1.0	....
77	76.3	19.9	3.8	84.0	16.0	7.0	....	....	....
78	76.3	20.0	3.7	84.2	15.8	....	3.1	1.2	7.162
79	76.3	20.0	3.7	84.3	15.7	5.4	....	9.0	6.801
80	76.3	20.5	3.2	86.4	13.6	....	2.4	7.8	....
81	76.3	20.5	3.2	86.5	13.5	....	5.4	....	....
82	76.3	21.0	2.7	88.7	11.3	8.7	....	7.8	7.169
83	76.3	21.3	2.4	89.6	10.4	.6	....	1.3	6.405
84	76.3	22.3	1.4	94.2	5.8	1.0	....	....	7.334
85	76.3	22.8	.9	96.1	3.9	2.3	....	4.1	....

analysis shows also CuO, 1.34; "Ta_2O_5, approximately 1.50, and Cb_2O_5, 0.70, judging from density of oxides." The quantity of tantalic and columbic pentoxides indicated is unusually high. The excess WO_3 shown seems to be combined with part of the CuO to form a hydrous copper tungstate new to science. Work is now being undertaken on this mineral. Part of the copper is probably combined with the SiO_2 as chrysocolla.

79. Ferberite from the Sierra Almagrera, southern Spain. Liebe, K. L. T., Ein neuer Wolframit; ein Beitrag zur Mineral-Chemie: Neues Jahrb., 1863 p. 645,. The analysis also shows Al_2O_3, 1.15; limonite, 1.39; SnO_2, 0.14; GlO, trace. The analysis as given follows Dana's recalculation after subtracting the limonite (System of Mineralogy, p. 985). The specific-gravity determination is stated to have been made by Breithaupt.

80. Ferberite from Kootenay Belle mine, Salmo, British Columbia. Walker, T. L., Report on the tungsten ores of Canada: Canadian Dept. Mines, Mines Branch, p. 38, 1909.

81. Ferberite from the American Tungsten Co.'s mine, Hill City, S. Dak. Analysis made at the South Dakota School of Mines. Quoted by C. H. Fulton in a private report on the mine. Traces of SnO_2 and S were found. If the quantities given are otherwise correct, it seems probable that a part of the substance determined as "SiO_2" is really CaO; hence the excess of WO_3.

82. Ferberite from the Sierra Almagrera, southern Spain. Rammelsberg, C. F., Ueber die chemische Zusammensetzung des Ferberits: K. preuss. Akad. Wiss. Berlin Monatsber., p. 175, 1865.

83. Ferberite from Adun-Tschilon, Siberia. Average of four analyses. Beck, W., and Teich, N., Ueber Wolfram und Scheelit aus Fundörten Russlands: Russ.-k. mineral. Gesell. St. Petersburg Verh., 2d ser., vol. 4, p. 315, 1869.

84. Ferberite from Ivigtut, Greenland. Analysis by Chr. Christensen. Bøggild, O. B., Mineralogia Groenland (Særtryke af Meddelelser om Grönland, vol. 32): Mineral. and Geol. Mus. Univ. Copenhagen, Contr. to Mineralogy No. 6, p. 182, 1905.

85. Ferberite from Last Chance, Boulder County, Colo. Analysis by J. B. Ekeley. George, R. D., The main tungsten area of Boulder County, Colo.: Colorado Geol. Survey First Rept., p. 42, 1909.

Analyses of minerals of

No.	Locality.	Original analysis.							
		WO_3.	FeO.	MnO.	CaO.	SiO_2.	MgO.	Other substances.	Total.
	FERBERITE—continued.								
86	Magnolia, Colo	73.94	23.85	0.67	0.60	0.49	0.12	Al_2O_3 0.25	99.92
87	Clyde mine, Colo	61.15	19.33	.51	.38	16.10	.39	Al_2O_3 2.49	100.35
88	Elsie mine, Colo	73.52	22.65	.60	.42	1.81	....	Al_2O_3 0.75	99.75
89	Manchester Lake, Colo	74.13	23.15	.56	1.28	.71	....	Al_2O_3 0.46	100.29
90	Puy-les-Vignes, France	72.24	27.19	.57	....	Trace.	....	....	100.00
91	Barker ranch, Colo	65.88	24.14	.37	.35	6.45	.50	Al_2O_3 2.19	99.88
92	Winnebago mine, Colo	71.01	24.82	.18	1.32	.71	....	Al_2O_3 2.25	100.59
93	Japan	75.214	24.372	.185	....	....	Trace.	....	99.77
94	Conger mine, Colo	60.98	19.13	.08	.44	15.94	.59	Al_2O_3 3.10	100.26
95	Kimbosan, Japan	75.47	24.33	....	Trace.	....	Trace.	Ta_2O_5, trace	99.80

86. Ferberite from Magnolia, Boulder County, Colo. Analysis by J. B. Ekeley. George, R. D., The main tungsten area of Boulder County, Colo.: Colorado Geol. Survey First Rept., p. 42, 1909.

87. Ferberite from Clyde Mine, Nederland, Boulder County, Colo. Analysis by Ekeley, J. B., The composition of some Colorado tungsten ores: Colorado Univ. Studies, vol. 6, No. 2, p. 95, 1909.

88. Ferberite from Elsie mine, Boulder County, Colo. Analysis by J. B. Ekeley. George, R. D., The main tungsten area of Boulder County, Colo.: Colorado Geol. Survey First Rept., p. 42, 1909.

89. Ferberite from claim near Manchester Lake, Gilpin County, Colo. Analysis by J. B. Ekeley. George, R. D., The main tungsten area of Boulder County, Colo.: Colorado Geol. Survey First Rept., p. 42, 1909.

90. Ferberite from Puy-les-Vignes, France. Analysis by Nicolardot quoted by Lacroix, A., Minéralogie de la France et de ses colonies, vol. 4, pt. 1, p. 282, 1910. The analysis shows a trace of SnO_2.

***the wolframite series*—Continued.**

No.	Recalculated analysis.								Specific gravity.
	WO₃.	FeO.	MnO.	FeWO₄.	MnWO₄.	Excess FeO.	Excess WO₃.	CaWO₄.	
86	76.3	23.0	0.7	96.9	3.1	2.3	....	3.1	....
87	76.3	23.0	.7	97.2	2.8	1.3	....	1.9	....
88	76.3	23.1	.6	97.3	2.7	1.1	....	2.6	....
89	76.3	23.1	.6	97.4	2.6	1.5	....	6.6	....
90	76.3	23.1	.6	97.5	2.5	5.3	....	....	....
91	76.3	23.3	.4	98.1	1.9	4.5	....	....	....
92	76.3	23.5	.2	99.1	.9	4.6	....	6.8	....
93	76.3	23.5	.2	99.2	8	1.2	....	....	7.079
94	76.3	23.6	.1	99.6	.4	.2	....	2.8	....
95	76.3	23.7	....	100.0	....	.8	....	....	6.640

91. Ferberite from the Barker ranch, Nederland, Boulder County, Colo. Analysis by J. B. Ekeley. George, R. D., The main tungsten area of Boulder County, Colo.: Colorado Geol. Survey First Rept., p. 42, 1909.

92. Ferberite from Winnebago mine, Gilpin County, Colo. Analysis furnished by E. M. Green, Rollinsville, Colo. The original gives: FeO, 22.11, and Fe_2O_3, 3.01. The ferric oxide has been calculated to its equivalent of ferrous oxide, and this seems to accord better with the remainder of the analysis.

93. Analysis of a pseudomorph of ferberite (reinite) after scheelite from Otomezaka or Kurasawa, Japan, by F. Kodera. Quoted by Tsunashiro Wada, Minerals of Japan (translated by Takudzi Ogawa), p. 77, 1904.

94. Ferberite from Conger mine, Nederland, Boulder County, Colo. Analysis by Ekeley, J. B., The composition of some Colorado tungsten ores: Univ. Colorado Studies, vol. 6, p. 95, 1909.

95. Ferberite (reinite) replacing scheelite, from Kimbosan, Kei, Japan. Analysis by E. Schmidt. Quoted by Luedecke, Otto, Ueber Reinit, K. v Fritsch, Ein neues Wolframsäures Eisenoxydul: Neues Jahrb., 1879, p. 288.

CONSIDERATION OF THE ANALYSES.

The collection of analyses just given indicates an essentially complete series of mixtures of manganese and iron tungstates ranging from pure manganese tungstate to pure iron tungstate, with the possible number of members limited only by the number of specimens analyzed and by the accuracy of the determinations. The series is analogous to those of the plagioclase feldspars and the columbite-tantalite group. The greatest difference between consecutive analyses in either hübnerite or wolframite molecules is 5.5 per cent, which is found between the wolframites from Lost River, Alaska (No. 34), and Vilate, France (No. 35), which contain, respectively, as recalculated, 56.7 per cent and 51.2 per cent $MnWO_4$, but there can be little doubt that analyses of other specimens from these or other localities would fall within the gap. It is also probable that if the exact quantity of iron and manganese combined as tungstates were known, the results would be considerably different. Most writers on the subject have treated the wolframites as definite compounds of $FeWO_4$ and $MnWO_4$, bearing relations to each other which could be expressed by small whole numbers, but this does not seem to be borne out by the analyses. Groups of analyses of wolframites from Zinnwald, from the Boulder district, and from the Black Hills, all small areas, show a very considerable variation in the ratio of iron and manganese bearing molecules. Those from Zinnwald range from 77.0 per cent to 60.2 per cent $MnWO_4$, and those from Boulder County range from 36.2 per cent to 0.4 per cent $MnWO_4$. In some crystals of hubnerite a considerable variation in color, probably due to difference in composition of different zones, can be seen. Were it not for the black color of each part, a zonal growth similar to that of porphyritic plagioclase feldspars could probably be observed in many wolframite crystals. (See Pl. XIII, p. 30.) As stated in another place by W. T. Schaller, no difference in crystal form can be noticed between the two ends of the series. If there were a series of definite compounds between the two end members, some expression of the fact would probably be found in the facial angles.

Attention is called to the number of wolframites whose analyses show the presence of tantalum and columbium. It is probable that in some analyses, particularly the earlier ones, other substances have been determined as these elements, and in other analyses they have not been recognized or determined when present. Dr. Eberhard showed spectroscopically (p. 18) that columbium was present in a specimen of Boulder County ferberite, but he made no test for tantalum. Where one element is present, however, the other is almost sure also to be there.

Tantalum and columbium are common in wolframites and their commercial possibilities have been investigated rather extensively.[1] Mennicke mentions 1.5 per cent as the highest content of the oxides known in wolframites, but the ferberite from Cave Creek, Ariz., carries 2.2 per cent of the combined Ta_2O_5 and Cb_2O_5, according to Wherry's analysis. The form in which these oxides are present is not positively known, but it seems probable that, as suggested by Damour,[2] they occur as minute particles of columbite. In the ferberite of Cave Creek irregularities in cleavage faces seem to be due to the presence of small bodies of a different black opaque mineral which may be columbite. I hope to do further work upon this subject.

DEFINITION OF FERBERITE AND OTHER MEMBERS OF THE WOLFRAMITE SERIES.

The continuity of the wolframite series as indicated by the analyses quoted shows that its customary division into hübnerite, wolframite, and ferberite must of necessity be arbitrary. The analysis on which the species ferberite is based (No. 79) gives a content of 3.02 per cent MnO, equivalent to 3.7 per cent MnO or 15.7 per cent $MnWO_4$ after recalculation. Great accuracy can not be claimed for the figures showing the constituent molecules, as the material was impure. In defining the species it can hardly be held that 3.07 per cent MnO or 15.7 per cent $MnWO_4$ must mark the extreme limit of Mn allowable in ferberite. As by common usage the wolframite series is divided into three groups, 20 per cent $MnWO_4$ seems to be a convenient and reasonable limit to place upon the $MnWO_4$ allowable in a ferberite, and convenience would seem to indicate for hübnerite a similar limit of 20 per cent for its content of iron tungstate, $FeWO_4$. For the mixtures between these end members the older term wolframite may properly be retained, and this term may well serve also as a general or field name for the members of the series which can not be definitely identified.

I therefore propose the following definitions for the members of the wolframite series:

Ferberite: A monoclinic iron tungstate having when pure the composition $FeWO_4$. It may contain not more than 20 per cent of the hübnerite molecule, $MnWO_4$.

Hübnerite: A monoclinic manganese tungstate having when pure the composition $MnWO_4$. It may contain not more than 20 per cent of the ferberite molecule, $FeWO_4$.

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[1] Mennicke, Hans, Die Metallurgie des Wolframs, pp. 125-130, 1911.

[2] Damour, A., Sur le wolfram tantalifère du département de la Haute-Vienne: Soc. géol. France Bull., 2d ser., p. 108, 1848.

Wolframite: A monoclinic mineral containing the ferberite molecule ($FeWO_4$) and the hübnerite molecule ($MnWO_4$) in all proportions between 20 per cent $FeWO_4$ and 80 per cent $MnWO_4$, and 80 per cent $FeWO_4$ and 20 per cent $MnWO_4$.

Under this scheme the analyses show ferberites from 13 widely separated localities—Boulder County, Colo., Cave Creek, Ariz., and Hill City, S. Dak., in the United States; British Columbia; Greenland; France; Saxony; Italy; Sierra Almagrera and Estremadura, Spain; New South Wales; India; Siberia; and Japan. The ferberite of Japan was described as reinite and replaces scheelite. From Limoges, France (No. 68), is shown a ferberite that contains nearly the maximum amount of manganese. The purest ferberite, showing no manganese and only a small excess of iron oxide (0.8 per cent), is that from Japan. Minerals from Gordon Gulch (No. 58) and Ward (No. 49), in the Boulder tungsten field, fall well within the wolframites, although from the most remarkable ferberite locality known. They merely emphasize the characteristic variability of the hübnerite-ferberite mixture.

EXCESS OF FERROUS OXIDE AND MANGANOUS OXIDE.

A point to which considerable importance has been attached by different writers is the excess of FeO in the ferberites, but the table of analyses shows that they are not unique in this, though some ferberites do carry large excesses of FeO.

The proneness of WO_3 to form a lower oxide on heating and its solubility make it seem probable that many determinations of the oxide are low, so that the appearance of an excess of 0.1 or 0.2 per cent FeO may be neglected. It is also probable that in many of the analyses the MnO is too high, a common error when the determination is made gravimetrically, and a very small excess of MnO would cause a somewhat larger apparent excess in the FeO. Only a few of the analyses show the presence of alumina, but many wolframites occur in a gangue containing muscovite or feldspar or both, and small quantities are likely to be mixed with the mineral analyzed. If the mineral is fused, the alumina, unless specially separated, will be precipitated with the iron oxide, and, if the iron is determined gravimetrically, will by so much make it appear larger.

Iron oxide is commonly present as such, for in the oxidized zone the breaking down of minerals such as siderite, pyrite, chalcopyrite, or wolframite sets free iron oxide, which may form films over the residual wolframite or fill cavities of microscopic or larger size. A cut and polished crystal of brown ferberite from the Winnebago claim near Rollinsville shows a very porous structure (see Pl. IV, *A*, p. 13) and the cavities are coated with hydrous iron oxide. This material is similar to that found on part of the Rogers tract and would surely give a considerable excess of iron on analysis. Specular hematite or magnetite, in particles too small to be easily distinguished, may occur in the ore, and the presence of one or both of these minerals may account for the surplus iron shown in some determinations.

In those wolframites which contain tantalum and columbium columbite may furnish a part of the apparent excess of iron. Microscopic examinations made by reflected light on polished and etched specimens of clean black ferberite show none of the differences in texture to be expected if such other minerals were present. There are, however, minute cavities which may be partly filled with iron minerals. Manganese dioxide, though in less quantity than iron oxides, is commonly associated with the ores, but its presence on the lighter-colored hübnerites should be easily distinguishable. The possibility of FeO and MnO being held in solid solution in the minerals of the wolframite series suggests itself, but no proof of this has been found.

It is to be noted that if the analyses given had been recalculated by first satisfying the FeO with WO_3, and then combining the remainder of the WO_3 with the MnO, the excess of the FeO would disappear in most of the analyses and there would be an excess of MnO. However, as just stated, manganese oxide occurs with the wolframites in much less quantity than iron oxide, and for this reason in recalculating an analysis it is best to first satisfy the MnO with WO_3. It appears, therefore, that though some of the wolframites may carry an excess of FeO, and a few an excess of both FeO and MnO, most if not all of the apparent excesses are due to impurities present in the material analyzed and to errors of analysis.

Many careful analyses of well-selected minerals and many examinations by metallographic methods must be made before a real excess of FeO or MnO in the wolframites can be demonstrated.

CRYSTALLOGRAPHY OF FERBERITE FROM COLORADO.

By Waldemar T. Schaller.

PREVIOUS PUBLICATIONS.

The several papers mentioned by Mr. Hess in his part of this report give some general facts in regard to the habit and size of crystals of ferberite. Two other papers, by Warren and by Moses (see Bibliography, pp. 74–75), give descriptions of ferberite crystals which may have come from this locality. The crystal figured by Warren is said to have come from South Dakota, though he states that the exact locality could not be ascertained. From the appearance of the crystal it is more likely to have come from Colorado than from South Dakota. The crystal figured and described by Moses as crystallized wolframite from Boulder County, Colo., is very similar to those here described.

These two papers are the only publications on the crystallography of the ferberite from Colorado that could be found.

GENERAL CHARACTER OF THE CRYSTALS.

MODE OF OCCURRENCE.

In the specimens examined the ferberite crystals are perched on the country rock in groups or they line or nearly fill the cavities or fissures in the matrix. Layers of ferberite several centimeters thick, consisting of crystals whose bases have coalesced, are found on the rock. Much of the ferberite, which at first glance seems to be massive, is found on closer inspection to be a granular compact mass of small crystals.

The crystals occur isolated as distinct individuals (Pls. VII, p. 18, and VIII, p. 19), in groups of parallel or nearly parallel individuals (Pls. IX, p. 20, and X, p. 21), or in confused masses consisting of numerous abutting and even penetrating crystals. Twins are common, though single untwinned crystals are far more plentiful. The nearly parallel groupings are of two kinds: (1) A group of flattened crystals which may depart several degrees from strict parallelism and which are joined by the *a*(100) faces (fig. 1); and (2) crystals joined by the *c*(001) faces and superposed, the line of demarcation of the different crystals being well shown by the irregular lines crossing the prism zone normal to the vertical striations (fig. 2). The distribution of the dome faces on several of the parallel groupings joined by the *a*(100) face conclusively demonstrates that the crystals are not twinned.

Well-developed crystals are abundant, but many crystals are rounded and curved either in a single zone or throughout. The curving of the surfaces in a single zone is generally due to the marked development of the striations in the prism zone. (See fig. 9, p. 59.) The curving of the faces over an entire crystal is due to the nearly parallel grouping of a number of crystals, each one deviating successively a little more from parallelism with the original unit.

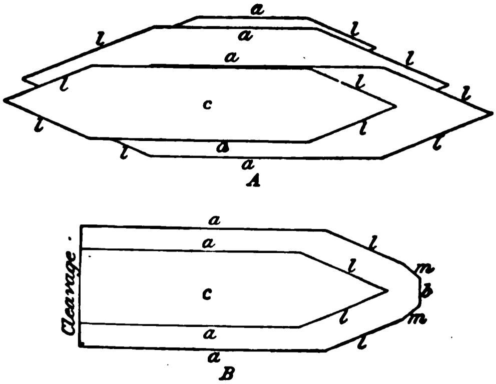

FIGURE 1.—*A*, Orthographic projection of crystals with similar combinations in parallel grouping, joined by the *a*(100) face; *B*, Orthographic projection of two crystals with dissimilar combinations. The cleavage parallel to $b(0\bar{1}0)$ in many crystals terminates one side. Forms: *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}.

The various forms of occurrence of ferberite found on the specimens examined may conveniently be summarized as follows:

1, Massive.
2, Bladed, indistinctly crystallized.
3, Distinct individual crystals.
  a, Single well-formed crystals (Pls. VII, VIII, XI, and XII, and text figs. 3–34).
  b, Twinned crystals (Pl. VIII,A, and text figs. 14, 15, 17, and 18).
  c, Crystals grouped in parallel position (Pls. IX and X).
    (1), Composition face *a*(100) (fig. 1).
    (2), Composition face *c*(001) (fig. 2).
  d, Rounded crystals or groups of crystals.

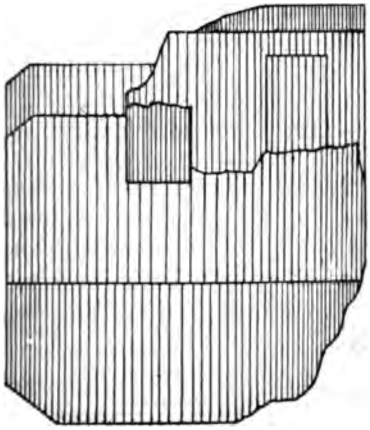

FIGURE 2.—Superposed crystals, joined by the *c*(001) faces. The line of demarcation is normal to the vertical striations on the large *a*(100) faces.

SIZE.

In size the crystals vary considerably. The largest seen were about 1.5 centimeters long (*b* axis), half as high (*c* axis), and about 4 millimeters thick (*a* axis). The general average would be about 5 to 10 millimeters long, 2 to 5 millimeters high, and 1 to 3 millimeters thick. On some of the rock specimens areas extending over many square centimeters are coated by minute crystals, few of which measure more than a millimeter in any direction. Most of the crystals measured were much smaller than the average. The dimensions of the crystals were accurately measured under the microscope, so that their proportions might be shown in the drawings for the text figures in this bulletin. Of 18 crystals thus accurately measured the *a* axis lay between 0.3 and 0.7 millimeter on 14 crystals; the *b* axis (which in most of these crystals has about half the true original value) between 0.5 and 2.5 millimeters on 16 crystals; and the *c* axis between 1.0 and 3.5 millimeters on 13 crystals. The extreme values are: *a* axis, 0.3 to 5.0 millimeters (the 5.0 is an extreme value, the next highest is only 1.5; all the other values are less than 1.0 millimeter); *b* axis, 0.6 to 3.2 millimeters; *c* axis, 0.3 to 3.8 millimeters.

Most of the crystals measured were bounded on one side by a cleavage face of $b(0\bar{1}0)$, so that the sizes here given do not actually represent the size of the original crystals in the direction of the *b* axis. In the illustrations (figs. 3 to 34) the crystals are generally shown relatively longer in the *b* axis than the measured values indicate, in order to represent more truly their actual original sizes. The *b* axis on many of the complete crystals was probably twice as great as measured.

COLOR AND CLEAVAGE.

The crystals are black and their luster is splendent, nearly metallic. The streak is dark brown, suggesting hematite. It is distinctly not black. Cleavage is clinopinacoidal, $b\{010\}$, very good, and commonly visible on the basal pinacoid.

THE MEASURED CRYSTALS BY LOCALITIES.

In the following table the crystals measured are grouped according to the mine from which they came. In addition their general character and habit are given for reference. These descriptions and localities are based entirely on the material collected by Mr. Hess. For other localities, not mentioned here, the papers given by Mr. Hess in his bibliography should be consulted.

List of crystals by localities.

Crystal No.	Locality.	Illustrated in figure—	Original notebook No.	Description and habit.[a]
1	Crystals 1-12 from 1 specimen of ore from the 100-foot level of the Hoosier mine, Boulder County, Colo.	4	A_1	S, prismatic.
2		11	A_2	S, wedgelike.
3		....	A_3	S, prismatic.
4		10	A_4	S, wedgelike.
5		22	A_5	S, prismatic.
6		23	A_6	Do.
7		....	A_7	Do.
8		....	A_8	S, wedgelike.
9		24	A_9	S, prismatic.
10		....	A_{10}	T, tabular.
11		14	A_{11}	Do.
12		....	A_{12}	Do.
13	Crystals 13-17 from 1 specimen from the Nugget claim, 5 miles southeast of Nederland, 1½ miles northeast of Rollinsville; Gilpin County, Colo. Specimen taken from a 17-foot winze.	25	B_1	S, prismatic.
14		....	B_2	Do.
15		....	B_3	Do.
16		26	B_4	G, prismatic.
17		27	B_5	S, prismatic.
18	Crystals 18-23, 24-25, 26-27, from three different specimens, all from the same claim as crystals 13-17 (Nugget claim).	28	C_1-1	Do.
19		29	C_1-2	Do.
20		30	C_1-3	G, prismatic.
21		....	C_1-4	S, prismatic.
22		....	C_1-5	Do.
23		....	C_1-6	T, tabular.
24		13	C_2-1	S, rhombic.
25		33	C_2-2	Do.
26		34	C_3-1	Do.
27		....	C_3-2	T, tabular.
28	Crystals 28-35 from one specimen from Town Lot mine, Nederland, Boulder County, Colo.	....	C_3-3	S, tabular.
29		19	D_1	S, wedgelike.
30		....	D_2	Do.
31		....	D_3	Do.
32		20	D_4	Do.
33		21	D_5	Do.
34		....	D_6	Do.
35		....	D_7	Do.
36	From Black Hawk claim, Boulder County, Colo....	31	E_1	S, cubic.
37		32	E_2	Do.
38	From Georgia A. vein, 2 miles northeast of Nederland, Boulder County, Colo.	6	F	Do.

[a] S, simple crystal; G, group of crystals in nearly parallel position; T, twin crystal.

AXIAL ELEMENTS.

The discussion of the axial elements of ferberite leads at once to the question of the relation of ferberite to the wolframite group.

In this connection a consideration of the relation in angular values between the pure iron tungstate and the pure manganese tungstate is of interest. The ferberite crystals at hand did not yield results as satisfactory as had been expected, because of the imperfection of the crystals, due to striations, parallel groupings, and like features; because of the scarcity of well-developed terminal forms; and because the high polish of most of the crystals had been destroyed by the hydrofluoric acid used to remove the matrix and clean the crystals.

CALCULATION OF VALUES.

Below are given the best measurements obtained that are suitable for the calculation of the axial elements, and these are compared with the measurements given in the literature for the members of the wolframite group. All measurements were made with a Goldschmidt two-circle goniometer.

Average of best measurements.

(010) : (110)

Fair reflection:
50° 16′
22
23
12
24
20
22
16
15

Poor reflection:
50° 31′
27
28
22
17
20
21

Average of 9 measurements with fair reflection, 50° 19′.
Average of 7 measurements with poor reflection, 50° 24′.
Average of the 16 measurements,[1] 50° 20½′.

(001) : (011)

Good reflection:
41° 00′
01
00
40 59
59
57
57
58
56
53
56

Average of 11 measurements, 40° 58′.

(010) : (210)

Good reflection:
67° 27′
23
24
26
25
31
25
32
21

Fair reflection:
67° 17′
23
16
28
19
27
30
26

Average of 9 measurements with good reflection, 67° 26′.
Average of 8 measurements with fair reflection, 67° 23′.
Average of the 17 measurements,[1] 67° 25′.

(001) : (102)

27° 46′
49
27 43
45
37
50

Average of 6 measurements, 27° 46′.

(001) : (100)

89° 50′
34
32
33

Average of 4 measurements, 89° 37′.

In the measurements of the prism angles the ϕ angle was obtained, this being the same as the angle (010) ∧ prism. The v_0 or zero reading on *b*(010) was averaged for each crystal from the readings obtained on (010) and (0$\bar{1}$0) (often a cleavage face), and from the average of (110) and (1$\bar{1}$0), and (210) and (2$\bar{1}$0), respectively. The *c*(001) faces were generally striated in the zone (001) : (100), but this in nowise interfered with the accuracy of the measurement of the angle (001) : (011). The accurate measurements from (001) to (102) and to (100) were very few in number, as the base (001) was striated in this direction on most of the crystals.

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[1] Good measurements weighted twice as much as fair ones; fair measurements weighted twice as much as poor ones.

COMPARISON OF VALUES.

Instead of deriving axial elements from these angular values I have compared the interfacial angles directly with the best ones I could find in the literature for the entire wolframite group. These have been arranged in order of decreasing percentage of MnO, so that the first lines in the table below represent hübnerite and the last lines (except the very last) represent ferberite. The very last line contains the values taken from Goldschmidt's Winkeltabellen, in which the axial elements of Descloizeaux, Krenner, and Seligmann have been averaged. (See Bibliography, pp. 74–75.) A careful study of the angular values given in any column does not show any regular increase or decrease corresponding with the regular decrease in percentage of MnO. In fact the variation in angular values for two or more wolframites of nearly the same composition is nearly as great as between the extreme end members. The correlation of the chemical composition and the crystallographic constants is doubtful in so far as the analytical figures given were not obtained on the material actually measured.

Comparison of angles with variation in chemical composition.

Locality and material.	Author.	Per cent MnO.	Angle.				
			(010):(110).	(010):(210).	(001):(011).	(001):(102).	(001):(100).
			° ′	° ′	° ′	° ′	° ′
$MnWO_4$ (artificial).	Groth and Arzruni.	23.4	50 15	....	....	....	....
Megabasite	....do..........	22.24	50 27½	....	....	....	....
Colorado........	Penfield........	21.93	50 06	67 19	40 55	27 12½	89 07½
$Mn_2Fe_3(WO_4)_5$ (artificial).	Groth and Arzruni.	9.4	50 21	....	40 51½	....	....
Saxony.........	Krenner.........	4.96	50 30	67 36	40 42½	27 29	89 39½
France.........	Descloizeaux....	4.84	50 18½	67 28	40 57	27 27½	89 21½
Spain..........	Seligmann.......	3.15	50 36	67 40	41 03½	27 50½	89 34
Colorado	W. T. Schaller..	.1	50 20½	67 25	40 58	27 46	89 37
$FeWO_4$ (artificial).	Groth and Arzruni.	.0	50 33	....	....	27 33	....
Average [a].......	Goldschmidt's Winkeltabellen.	....	50 27	67 34½	40 54	27 35	89 32

[a] Computed from axial elements of Descloizeaux, Krenner, and Seligmann.

A definite, measured difference in crystallographic constants between ferberite ($FeWO_4$) and hübnerite (MnO_4) is not shown by the table just given. The average axial elements given by Goldschmidt represent closely the angular values for the different members of the wolframite group. These values are also close to those obtained on the Colorado ferberite as shown below.

Comparison of angles of ferberite from Colorado with the values given in Goldschmidt's Tables.

Angle.	Goldschmidt's Winkeltabellen.	Boulder County ferberite.	Difference.
	° ′	° ′	′
(010):(110)........	50 27	50 20½	−06½
(010):(210)........	67 34	67 25	−09
(001):(011)........	40 54	40 58	+04
(001):(102)........	27 35	27 46	+11
(001):(100)........	89 32	89 37	+05

The axial elements given by Goldschmidt, namely, $a:b:c = 0.8255:1:0.8664$, $\beta = 89° 32'$, therefore best represent the constants for the entire wolframite group.

The data for the percentages of manganese given in the table on page 45 have been taken from Dana.[1] Descloizeaux's measurements were made on material from Vilate, near Chanteloube (Haute-Vienne), France. An analysis of wolframite from Chanteloube shows 4.84 per cent MnO and 19.32 per cent FeO. Krenner's measurements were made on crystals from Ehrenfriedersdorf, Saxony, and an analysis of material from the same locality shows 4.96 per cent MnO and 19.16 per cent FeO. Seligmann's ferberite from Sierra Almagrera, Spain, contains 3.15 per cent MnO and 19.95 per cent FeO, according to Doelter.[2] Two confirmatory analyses of the Spanish ferberite show 3.00 and 3.02 per cent MnO with high FeO. Hübnerite from Colorado[3] showed 21.93 per cent MnO and 2.91 per cent FeO. "Megabasite" from Schlaggenwald contained 22.24 per cent MnO and 3.74 per cent FeO.

FORMS AND ANGLES.

A total of 32 forms were determined on the ferberite crystals from Colorado. Of these 12 are new for the wolframite group. These 32 forms are given in the table below with the measured and calculated coordinate angles. The new forms are marked with an asterisk (*).

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[1] Dana, E. S., System of mineralogy, 6th ed., p. 984, 1892.

[2] Zeitschr. Kryst. Min., vol. 11, p. 348, 1887.

[3] Penfield, S. L.; see Dana, E. S., op. cit., pp. 983, 984.

List of forms and angles on ferberite crystals.

[New forms are marked with an asterisk.]

No.	Letter.	Symbol.		Measured.		Calculated.	
		Gold-schmidt.	Miller.	ϕ	ρ	ϕ	ρ
				° ′	° ′	° ′	° ′
1	*c*	0	001	90 00	0 23	90 00	0 28
2	*b*	0 ∞	010	0 00	90 00	0 00	90 00
3	*a*	∞ 0	100	90 12	90 00	90 00	90 00
4	*r*	∞ 2	120	33 49	90 00	31 12	90 00
5	*m*	∞	110	50 21	90 00	50 27	90 00
6	*l*	2 ∞	210	67 25	90 00	67 31	90 00
7	**R*	$\frac{15}{7}$ ∞	15.7.0	69 00	90 00	68 56	90 00
8	**C*	$\frac{9}{4}$ ∞	940	70 01	90 00	69 51	90 00
9	**F*	$\frac{5}{2}$ ∞	520	71 39	90 00	71 44	90 00
10	*Q*	$\frac{8}{3}$ ∞	830	73 19	90 00	72 48	90 00
11	*d*	3 ∞	310	74 47	90 00	74 37	90 00
12	**G*	$\frac{7}{2}$ ∞	720	76 45	90 00	76 44	90 00
13	**M*	5 ∞	510	80 30	90 00	80 38	90 00
14	**N*	$\frac{11}{2}$ ∞	11.2.0	81 35	90 00	81 28	90 00
15	*j*	6 ∞	610	82 00	90 00	82 10	90 00
16	**L*	7 ∞	710	83 08	90 00	83 16	90 00
17	*n*	8 ∞	810	84 20	90 00	84 06	90 00
18	*f*	0 1	011	0 04	40 54	0 32	40 54
19	*u*	+ $\frac{1}{4}$ 0	104	90 00	16 28	90 00	15 08
20	*t*	+ $\frac{1}{2}$ 0	102	90 00	27 46	90 00	28 03
21	**H*	+ $\frac{9}{4}$ 0	904	90 00	66 31	90 00	67 07
22	*γ*	− $\frac{1}{11}$ 0	$\bar{1}$.0.11	90 00	4 20	90 00	4 59
23	**B*	+ $\frac{1}{3}$ $\frac{2}{3}$	123	31 10	34 13	31 47	34 12
24	**E*	+ $\frac{5}{14}$ $\frac{9}{14}$	5.9.14	34 25	33 48	34 31	34 03
25	*ω*	+ 1	111	50 25	53 45	50 40	53 49
26	*λ*	+ $\frac{1}{2}$	112	50 16	34 24	50 53	34 29
27	**A*	+ $\frac{3}{7}$	337	50 45	30 37	50 58	30 31
28	*p*	+ $\frac{1}{2}$ $\frac{1}{4}$	214	69 42	31 22	67 53	29 55
29	**D*	+ 1 $\frac{1}{3}$	313	74 21	47 21	74 44	47 38
30	*s*	−12	$\bar{1}$21	30 14	63 45	31 00	63 41
31	*e*	− $\frac{1}{2}$	$\bar{1}$12	50 16	34 27	50 01	33 59
32	*o*	− 1	$\bar{1}$11	50 26	53 48	50 14	53 34

NEW FORMS.

A somewhat detailed description is given of the new forms found on the crystals. They may be grouped as follows:

Groups of new forms on ferberite crystals.

New prisms	7
New positive domes	1
New positive pyramids	4
	12

*Measurements of *R*{15.7.0}.

Crystal No.	Reflection.	Size of face.	ϕ (calculated 68° 56′).
			° ′
23	Fair	Narrow	68 57
31	Good	do.	68 49
18	Fair	do.	69 14

On crystal 23, the new form, *R*, lies between *l*{210} and *Q*{830} as a very narrow face, giving a distinct signal. The faces measured in one-half the prism zone are (010), (110), (210), (810), (100); (010), $(\bar{1}10)$, $(\bar{2}10)$, $(\overline{15}.7.0)$, $(\bar{8}30)$, $(\bar{1}00)$.

On crystal 31, three faces lying very close together gave good signals, and the measurements showed the presence of the three forms *l*{210}, *R*{15.7.0}, and *C*{940}.

On crystal 18 a part of the prism zone (see description of *C*{940}, crystal 18) showed the forms *Q*{830}, *C*{940}, *R*{15.7.0}, and *l*{210}.

In all the three occurrences of *R*{15.7.0} the form is associated with *l*{210} and in two of them it lies between *l*{210} and *C*{940}. From these facts, as well as the close agreement in measured and calculated values, the form is considered as definite and well established.

Measurements of **C*{940}.

Crystal No.	Reflection.	Size of face.	φ (calculated 69° 51′).
			° ′
18	Fair	Narrow	69 49
31	Good	....do	69 53
1	Poor	Line face	70 21

On crystal 18 the form was one of three faces lying close to *l*{210} and between it and *a*{100}. They form alternating narrow faces, but the signals they gave were clear and distinct. The faces were not striated. The prism zone is incomplete, the piece measured being only a fragment of a crystal. The other three forms present in the zone are *Q*{830}, *R*{15.7.0}, and *l*{210}.

On crystal 31 the three forms *l*{210}, *R*{15.7.0}, and *C*{940} lie close together and form alternating nonstriated faces similar to those observed on crystal 18. The other parts of the prism zone are not measurable, so that the presence on this crystal of other faces of the last two forms could not be confirmed.

On crystal 1 the form was noted once as a line face between *a*(100) and a cleavage face of $b(0\bar{1}0)$. On other parts of the crystal the form was absent.

Measurements of **F*{520}.

Crystal No.	Reflection.	Size of face.	φ (calculated 71° 44′).
			° ′
1	Poor	Line face	71 55
22	....do	....do	71 23

On crystal 1 the new prism was noted once with the forms *a*{100}, *m*{110}, *b*{010}. On crystal 22 the portion of the zone with the new prism was richer in faces, those present being *b*(010), *m*($\bar{1}$10), *l*($\bar{2}$10), *F*($\bar{5}$20), *a*($\bar{1}$00). The new form *F* is considered as established, though the agreement between the angles is not so good as for the two more complex symbols just described.

Measurement of **G*{720}.

	ϕ (calculated 76° 44').
Crystal No. 14	76° 45'

The new prism *G* was observed only once as a narrow face yielding a fair reflection. It formed one of four faces lying very close together, each of which, however, gave a distinct signal. These four faces, lying between *m*(110) and *a*(100), are *G*(720), a face near (410) but not determinable, *M*(510). and *N*(11.2.0).

Measurements of **M*{510}.

Crystal No.	Reflection.	Size of face.	ϕ (calculated 80° 38').
			° '
13	Good	Narrow	80 21
1	Poor	do	80 58
14	Fair	do	80 12

The new prism *M* is always associated with several other rare prisms. Narrow faces of it were found on crystal 13 with *n*(810), *a*(100), *n*(8$\bar{1}$0), *M*(5$\bar{1}$0); on crystal 1 as a striated face with *b*(010), *m*(110), *F*(520), *a*(100), *M*(5$\bar{1}$0), *l*(2$\bar{1}$0), *m*(1$\bar{1}$0), and *b*(0$\bar{1}$0); and on crystal 14 with *G*(720).

Measurements of **N*{11.2.0}.

Crystal No.	Reflection.	Size of face.	ϕ (calculated 81° 28').
			° '
14	Fair	Narrow	81 26
14	do	do	81 31
17	do	Broad	81 48

The two faces of *N* on crystal 14 are both narrow and both occurred with other prisms, but each with different forms. With one of them the associated forms were *m*($\bar{1}$10), *G*($\bar{7}$20), a face near ($\bar{4}$10), *M*($\bar{5}$10), *N*($\overline{11}$.2.0) and *a*($\bar{1}$00); with the other the forms were *n*($\bar{8}$10), *L*($\bar{7}$10), and *N*($\overline{11}$.$\bar{2}$.0). On crystal 17 *N* occurred with *a*(100), *n*(810), and *l*(210), being broader than either *l* or *n*.

*Measurements of *L*{710}.

Crystal No.	Reflection.	Size of face.	φ (calculated 83° 16′). ° ′
14	Fair..........	Narrow.......	83 19
5	Poor..........	Broad........	83 11
5	Fair..........	.....do........	82 55

The occurrence of *L*{710} on crystal 14 has already been noted under *N*{11.2.0}. On crystal 5 it is present twice as broad faces, in each case unaccompanied by other rare prisms and forming the only face between *a*(100) and *l*(210).

*Measurements of *H*{904}.

Crystal No.	Reflection.	Size of face.	ρ (calculated 67° 07′). ° ′
13	Poor..........	Line face......	67 06
14	.....do........	.....do........	67 13
24	.....do........	.....do........	67 38
15	No reflection..	.....do........	[a] 66
16	.....do........	.....do........	[a] 67
19	.....do........	.....do........	[a] 66
28	.....do........	.....do........	[a] 69
31	.....do........	.....do........	[a] 68
26	....	.....do........	([b])
34	....	.....do........	([b])
20	....	.....do........	([b])
27	....	.....do........	([b])

[a] Approximate. [b] Not measured.

This new dome, always present as a line face, was noted on 12 crystals, as shown in the table. The reflections from the faces were either very poor or not discernible, so that the approximate measurements (expressed only in degrees) were made by using the position of maximum illumination. The form is near to the simpler one {201}, but the measurements show that {904} are the correct symbols. The calculated ρ angle for the form {201} is 64° 37′.

Figures 25, 26, 29, 30, 33, and 34 show the new form *H*{904}.

*Measurements of *B* {123}.

Crystal No.	Reflection.	Size of face.	φ (calculated 31° 47′). ° ′	ρ (calculated 34° 12′). ° ′
13	Poor..........	Small..........	31 22	34 21
19	.....do........	Line face......	30 58	34 05

On crystal 13 the small face of *B* gave a poor but distinct reflection. The occurrence is illustrated in figure 25 (p. 66), an ideal representation of the crystal, which shows two faces of the form. The second side of the crystal is, however, not present, as a cleavage face of $(0\bar{1}0)$ terminates that side of the crystal. On crystal 19 the form *B*{123} is represented by a line face lying between *E*{5.9.14} and *f*{011}, both of which are larger than *B*. This occurrence is represented in figure 29 (p. 67). The form is probably also present on crystal 20, where a nonmeasurable line face was observed between Δ\{112\} and *f*{011}, though it could not be determined whether the form was {123} or {5.9.14}.

Measurements of **E*{5.9.14}.

Crystal No.	Reflection.	Size of face.	ϕ (calculated 34° 31′).	ρ (calculated 34° 03′).
			° ′	° ′
19	Poor..........	Small..........	34 21	33 50
20	.....do..........	.....do..........	34 20	34 02
27	.....do..........	Line face......	34 35	33 31

The first two occurrences of *E*{5.9.14} are small faces, much wider than the usual line faces and, as shown in figure 29 (p. 67), the face on crystal 19 reaches a fair size, whereas the corresponding simpler form *B*{123} is present as a line face. On crystal 20 (fig. 30, p. 68) the small face of *E*{5.9.14} lies between Δ\{112\} and *f*{011} and also attains an appreciable size. On crystal 27, however, it is present as a mere line face.

The symbols for the form *E* are rather complex and unusual, but the identification of the form on three crystals, the small distinct faces, and the close agreement between measured and calculated angles show that the form is well established.

Measurements of **A*{337}.

Crystal No.	Reflection.	Size of face.	ϕ (calculated 50° 58′).	ρ (calculated 30° 31′).
			° ′	° ′
13	Poor..........	Line face......	50 47	31 08
15	.....do..........	.....do..........	51 00	30 12
20	.....do..........	.....do..........	51 00	30 05
21	.....do..........	.....do..........	50 13	31 03

The form *A* is characteristically a line face between *c*{001} and Δ\{112\}. The only forms in this zone observed on these crystals are *m*{110}, ω\{111\}, Δ\{112\}, *A*{337}, *c*{001}, *e*$\{\bar{1}12\}$, and *o*$\{\bar{1}11\}$. The form is shown in figures 25 and 30 (pp. 66, 68).

**D*{313}. Only one face of this new form was observed, this being on crystal 19, where a small face yielded a fair reflection whose measurement gave ϕ, 74° 21′ (calculated 74° 44′); ρ, 47° 21′ (calculated 47° 38′). The form is shown in figure 29 (p. 67).

FORMS PREVIOUSLY DESCRIBED.

COMMON FORMS.

The common forms merit only a brief description, as their relative development and occurrence can well be seen by studying the drawings illustrating the different combinations and habits.

In the prism zone the orthopinacoid *a*{100} is always strongly striated vertically. These striations are not shown in the crystal drawings. The orthopinacoid is often replaced by vicinal forms several degrees from the true position of *a*{100}. On other crystals the faces of *a*{100} are very close to their true position of 90° 00′. No connection could be traced between the presence of vicinal forms replacing *a*{100} and the presence of new or rare prisms, as the following table shows:

Measurements of a{100} and list of associated prisms.

Crystal No.	ϕ		Remarks.
	°	′	
1	90 90	06 55	{120}, {940}, {520}, {510} present.
3	86	00	No new or rare prisms present.
4	86	57	Do.
5	90 87	07 47	{810}, {710} present. {710} present.
7	87 88	02 35	No new or rare prisms present.
8	87	38	Do.
10	90 90	06 11	Do.
13	89	53	{810}, {510} present.
14	90	49	{720}, {510}, {11.2.0}, {810}, {710} present.
22	86	49	{810}, {520} present.
23	88	15	{810}, {15.7.0}, {830} present.
32	89	30	{810} only rare prism present.
34	88 88	24 22	No new or rare prisms present.
35	88 86	26 45	Do.

The common prisms *l*{210} and *m*{110} are striated on some crystals and free from any striæ on others, those without striæ yielding good and distinct reflections.

The base *c*{001} is generally rounded in the zone {001}:{100}, commonly giving several reflections, the extreme ones on some crystals being several degrees apart.

The faces of *f*{011}, generally small, all gave good and distinct signals; those of *t*{102} were generally distinct, although on a few crystals they were somewhat blurred.

The pyramids are generally so small that the reflections from their faces are faint. The striations on *Δ*{112} cause the large faces of this form to yield indistinct and blurred signals. The striations are shown in figure 28 (p. 67).

RARE FORMS.

A number of rare forms which were observed on these crystals are entitled to a short discussion. The results are also applied to the tabulation of the forms of the wolframite group as developed on a later page.

r{120}, already noted by Descloizeaux and Jeremejew,[1] is probably present as a line face on crystal 1; ϕ measured 33° 49′ (calculated 31° 12′).

Q{830}, found by Penfield on hübnerite from Colorado,[2] is verified by the presence of two line faces on the crystals herein described. On crystal 18 a line face yielded a fair reflection whose measurement gave ϕ a value of 73° 06′ (calculated 72° 48′); crystal 23 showed a very narrow face, the measurement of whose reflection gave ϕ a value of 73° 32′ (calculated 72° 48′). Penfield's[2] letter *q* was changed[3] to *Q*, as *q* had already been preempted by the form {103}.

d{310}, noted by Krenner, Bøggild, and as doubtfully present by Moses, was found once on crystal 9 as a very narrow face, giving a poor reflection. ϕ measured 74° 47′ (calculated 74° 37′). The occurrence is illustrated in figure 24 (p. 66).

j{610} was first described by Bøggild, who assigned to the new form the letter *p*. As this letter had been used by Moses to designate the form {214}, I have changed Bøggild's *p* to *j*, as here given. The form was noted once, on crystal 9, as a medium-sized striated face; ϕ measured about 82° (calculated 82° 10′). The form is shown in figure 27 (p. 67).

n{810}, first noted by Groth and Arzruni, has been observed a number of times on these crystals. Some occurrences are shown in figures 22, 25, and 27. The angles measured are as follows:

Measurements of n{810}.

Crystal No.	Reflection.	Size of face.	ϕ (calculated 84° 06′).
			° ′
5	Fair	Large	84 13
13	do.	Narrow and striated	83 50
14	do.	Narrow	84 23
17	do.	do.	84 52
32	do.	Narrow and striated	84 20

u{104}, observed only by Jeremejew, is confirmed by finding it on crystal 13 as a line face with *t*(102) and *H*(904), as shown in figure 25 (p. 66). The reflection was very poor and its measurement gave ρ 16° 28′ (calculated 15° 08′).

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[1] See Bibliography, pp. 74-75, for references.

[2] Dana's System of mineralogy, 6th ed., p. 982.

[3] Goldschmidt's Winkeltabellen, p. 366, 1897.

$\gamma\{\bar{1}.0.11\}$, the only negative dome observed on any of these crystals, was first noted by Groth and Arzruni and is verified by finding it on three of these crystals. The reflections were, however, very poor, owing to the rounded and striated character of the faces. For comparison the original measurement of Groth and Arzruni is added to the table below. The ρ angle, as here given, is equal to $(001 \wedge \bar{1}.0.11) - (90^\circ - \beta)[=0^\circ\ 28']$. The calculated values of ρ for $\{\bar{1}.0.10\}$ and $\{\bar{1}.0.12\}$ are also added, and though my own measurements would agree better with these two forms, it is preferable, on account of the poor quality of the reflections, to assign them to the known form $\gamma\{\bar{1}.0.11\}$.

Measurements of $\gamma\{\bar{1}.0.11\}$.

Crystal No.	Reflection.	Size of face.	ρ (calculated 4° 59′).
			° ′
6	Poor..........	Line face......	3 51
9	.....do........	.....do........	5 23
35	.....do........	.....do........	3 46

As measured by Groth and Arzruni, $\rho = 4^\circ\ 59\frac{1}{2}'$.
ρ calculated for $\{\bar{1}.0.10\} = 5^\circ\ 32'$.
ρ calculated for $\{\bar{1}.0.12\} = 4^\circ\ 32'$.

The form $\gamma\{\bar{1}.0.11\}$ is illustrated in figures 23 and 24 (p. 66).

p{214} was first described by Moses on a crystal from Boulder County, Colo. It was also noticed by me as narrow faces on crystals 19, 29, and 30 (see figs. 19 and 29, pp. 64, 67), lying in the zone *c*(001): *l*(210). The faces gave poor reflections. The angles measured by Moses are also shown in the table below.

The form was measured on crystal 19 with the following result:

Measurements of p{214}.

Angle.	Calculated.	Measured.	
		Schaller.	Moses.
	° ′	° ′	° ′
ϕ.......	67 53	69 42	68 46
ρ.......	29 55	31 22	30 17

In addition to the measurements of *p*{214} given above, the form was identified on crystals 29 and 30. These crystals, however, were so incompletely developed that they could not be well placed in polar position. The angle between *p*(214) and *l*(210) was therefore measured, with the following results:

Measurements of angle p(214): *l*(210).

	° ′
Crystal 29..	58 39
Crystal 30..	60 05
Calculated..	60 05

On all three of these crystals the form occurred in the zone *c*(001): *l*(210), and on crystal 19 it was also determined to lie in the zone of and between *t*(102) and *Δ*(112), so that its determination as (214) is verified by its zonal relations.

DISCUSSION OF THE PRISM ZONE.

The prism zone contains numerous forms of somewhat complex symbols and a discussion[1] of these forms is here given in order to show how closely the forms approach the normal series.

The entire prism zone from *b*(010) to *a*(100) shows, when plotted in gnomonic projection (see fig. 35, p. 70), a partition into three parts, the points of division being *m*(110) and *d*(310). The three zone segments are then:

(1) *b*(010), *r*(120), *S*(7.11.0), *m*(110).
(2) *m*(110), *l*(210), *R*(15.7.0), *C*(940), *F*(520), *Q*(830), *d*(310).
(3) *d*(310), *G*(720), *M*(510), *N*(11.2.0), *j*(610), *L*(710), *n*(810), *a*(100).

In the following discussion, these three segments are taken up in turn:

(1) *Zone segment b......m.*

Form	*b* 010		*r* 120	*S* 7.11.0	*m* 110
Symbol$=\frac{h}{k}$	0		$\frac{1}{2}$	$\frac{7}{11}$	1
$\frac{v}{1-v}$	0		1	$\frac{7}{4}$	∞
N_2	0	$\frac{1}{2}$	1	2	∞

In place of $\frac{7}{4}$ or (7.11.0), the simple form 2 or (230) should occur. The form *S*(7.11.0) was not observed by me but was described by Warren. The measured angle (7.11.0) : ($\bar{7}$.11.0) is given as 74° 51′, whereas the calculated angle (230) : ($\bar{2}$30) is 77° 50′, a difference too great to allow of the form being referred to the symbol (230). Compare also the remarks on page 69 on the indices of this form.

(2) *Zone segment m......d.*

Form	*m* 110	*l* 210	*R* 15.7.0		*C* 940			*F* 520	*Q* 830	*d* 310
Symbol$=\frac{h}{k}$	1	2	$\frac{15}{7}$		$\frac{9}{4}$			$\frac{5}{2}$	$\frac{8}{3}$	3
$v-1$	0	1	$\frac{8}{7}$		$\frac{5}{4}$			$\frac{3}{2}$	$\frac{5}{3}$	2
$\frac{v}{2-v}$	0	1	$\frac{4}{3}$		$\frac{5}{3}$			3	5	∞
$v-1$		0	$\frac{1}{3}$		$\frac{2}{3}$			2	4	∞
N_3		0	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{2}{3}$	1	$\frac{3}{2}$	2	3	∞

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[1] For a description of the methods of the discussion, see Hillebrand, W. F., and Schaller, W. T., The mercury minerals from Terlingua, Tex.: *U. S. Geol. Survey Bull.* 405, p. 13, 1909.

The forms fit well into the normal series notwithstanding their complex indices.

(*3*) *Zone segment d......a.*

Form	*d*	*G*	*M*		*N*		*j*		*L*	*n*	*a*
	310	720	510		11.2.0		610		710	810	100
Symbol $=\frac{h}{k}$	3	$\frac{7}{2}$	5		$\frac{11}{2}$		6		7	8	∞
$r-3$	0	$\frac{1}{2}$	2		$\frac{5}{2}$		3		4	5	∞
$r-2$			0		$\frac{1}{2}$		1		2	3	∞
N_3			0	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{2}{3}$	1	$\frac{3}{2}$	2		∞

All the new prisms fit well into the normal series.

HABIT.

Five very distinct habits were observed on the crystals examined, habit meaning the relative development and size of the different crystal faces and the consequent resultant shape of the crystal as a whole. Thus twin crystals are not considered as necessarily of different habit from a simple untwinned crystal. These five habits are as follows:

1. Long, narrow, wedge-shaped. This is the habit most frequently observed for the ferberite crystals studied. This is the habit of the penetration twins (figs. 17 and 18, p. 64) but not of the contact twins. (See Pls. VII and VIII, *A*, pp. 18, 19, and fig. 3.)
2. Short, prismatic, somewhat flattened parallel to the orthopinacoid *a*{100}. Crystals of this habit are fairly abundant. (See Pls. IX, p. 20, and X, p. 21, and fig. 4.)
3. Tabular, parallel to *a*{100}. Rarely observed in simple crystals but the common habit for the individuals of a contact twin. (See fig. 5, also the twin crystals shown in figs. 14 and 15, p. 63.)
4. Cubic, rare. (See Pl. VIII, *B*, p. 19, and fig. 6.)
5. Rhombic, fairly abundant. (See Pls. XI, p. 22, and XII, p. 23, and fig. 7.)

Besides the habits mentioned above, two forms were noted which owe their shape to the cleavage of the crystals and are therefore not habits of the mineral. The first of these forms occurs in thin plates, which, as can be seen by reference to figure 8, *A* (p. 58), owe their tabular appearance to the *b*{010} cleavage. The complete crystal from which this thin plate was cleaved was probably of the fourth or cubic habit. The second form occurs in long, slender rods and likewise owes its peculiarity of form to cleavage. As illustrated in figure 8, *B*, it is probably derived from the edge of a crystal of habit 1 (see figs. 3 and 9), where the prism *l*{210} extended to the edge of the crystal.

Habit 1. The wedge-shaped crystals are generally striated in the prism zone with the forms *a*{100}, *l*{210}, and *m*{110} grading into one another, as shown in figure 9. On many crystals, however, the individual prism faces are sharply separated and commonly yield single distinct reflections. Figure 10 (crystal 4) also represents a typical crystal of this habit. On removing these crystals from the matrix, to which they are firmly attached, they usually cleave, and the resulting loosened crystal piece will consequently be much shorter in the

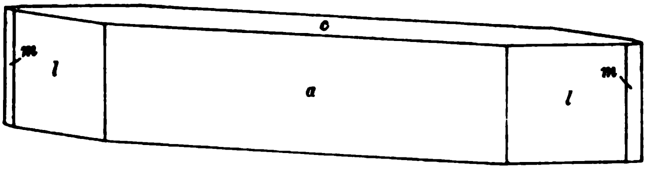

FIGURE 3.—Long, narrow, wedge-shaped crystal of habit 1, the most frequently observed habit. Forms: *c*{001}, *a*{100}, *m*{110}, *l*{210}.

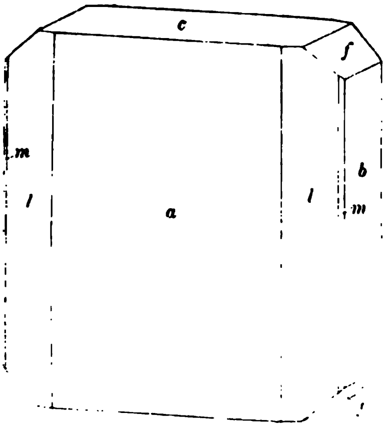

FIGURE 4.—Short, prismatic, somewhat flattened crystal of habit 2. Fairly abundant. Forms: *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}, *f*{011}.

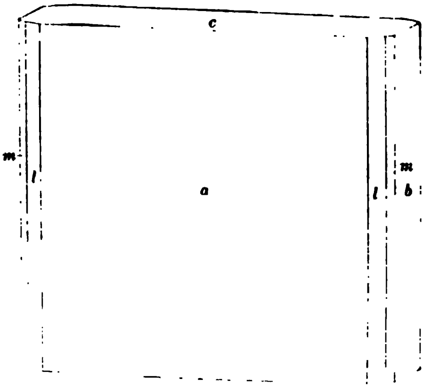

FIGURE 5.—Tabular crystal of habit 3. Common habit for contact twins, but rare for single crystals. Forms: *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}.

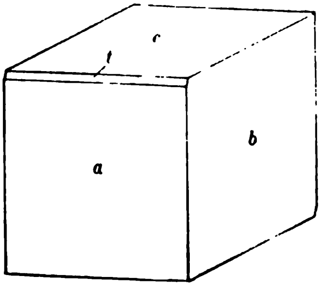

FIGURE 6.—Cubic crystal of habit 4. Rare. Forms: *c*{001}, *b*{010}, *a*{100}, *t*{102}.

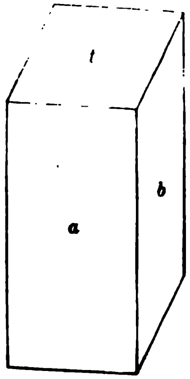

FIGURE 7.—Rhombic crystal of habit 5. Fairly abundant. Forms: *b*{010}, *a*{100}, *t*{102}.

direction of the *b* axis than the original crystal. From the sharp edge on one side such cleaved pieces show a peculiar axlike shape. (See fig. 11, crystal 2.) The penetration twins (figs. 17, 18, p. 64, and Pl. VIII, *A*, p. 19) are generally of this habit, and the contact twins (figs. 14 and 15, p. 63) are of the tabular or third habit. The wedge-shaped crystals of this first habit are generally poor in forms, few being found except the common ones, *a*{100}, *c*{001}, *l*{210}, *m*{110}, *b*{010}, *f*{011}.

Habit 2. The short prismatic habit, somewhat flattened parallel to *a*{100}, is the common habit for the wolframite group in general and is fairly abundant on the Colorado ferberite. An example was shown in figure 4 (crystal 1), and figure 12 illustrates the same combination as shown in figure 4, but with a habit intermediate between the first or wedge shaped and the second or short prismatic. The two habits show all gradations, and it is impossible to refer some crystals to one of these two habits rather than to the other. Figure 12 does not illustrate any particular crystal measured, but many were seen having about the relative proportions shown in the figure.

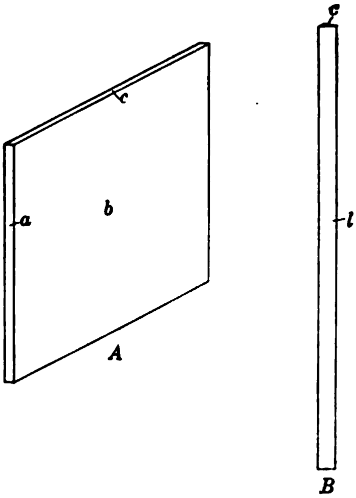

FIGURE 8.—Cleavage pieces of crystals. *A*, thin tabular; *B*, long, prismatic. Forms: *c*{001}, *b*{010} cleavage, *a*{100}, *l*{210}.

Habit 3. The tabular habit may be considered as a further development of the change from habit 1 to habit 2, which is intermediate between habits 1 and 3. Single crystals of this habit, as shown in figure 5, are rare, but in contact twins they are fairly abundant. The orthopinacoid, *a*{100}, is strongly striated in the twin crystals of this habit, whereas the other forms in the prism zone are in general nearly free of striæ.

Habit 4. The cubic crystals were found abundantly on one specimen, a side of which was literally covered with them (Pl. VIII, *B*, p. 19, and fig. 6). They were small, few being over a millimeter in length, and were highly iridescent. Some of the crystals are slightly elongated in the vertical direction, whereas others are nearly perfectly cubic. The shape of the crystals is conditioned by the combination being essentially that of the three pinacoids, *a*{100}, *b*{010}, *c*{001}, two of which are at right angles to each other, and the third very nearly so, the angle being 89° 32′. The dome *t*{102} is always present, and the pyramid *Δ*{112} is usually developed. The crystals of this habit are very poor in forms.

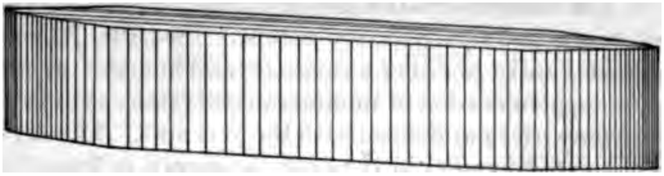

Figure 9.—Striations on wedge-shaped crystals of habit 1, causing a rounded appearance in the prism zone. The top base is also slightly striated and in some crystals rounded.

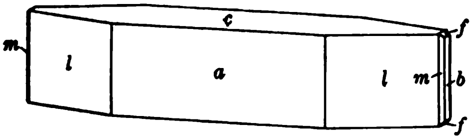

Figure 10.—Crystal 4, wedge-shaped habit, which has sharp, distinct faces, not rounded as in figure 9. Forms: *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}, *f*{011}.

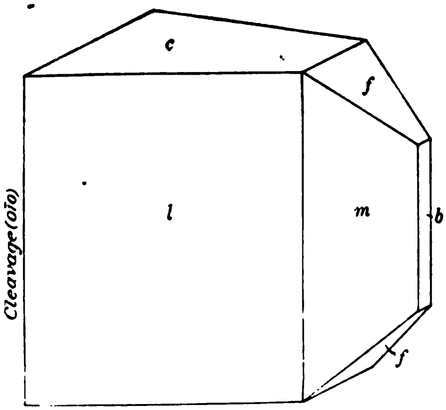

Figure 11.—Peculiar shape of crystals of wedge-shaped habit caused by cleavage on *b*{010}. Crystal No. 2. Forms: *c*{001}, *b*{010}, *m*{110}, *l*{210}, *f*{011}.

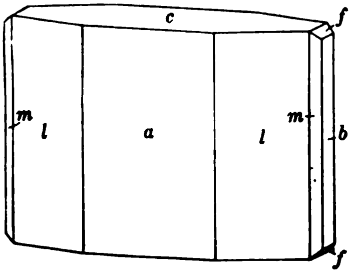

Figure 12.—Crystal of a short prismatic, somewhat flattened habit. Forms: *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}, *f*{011}.

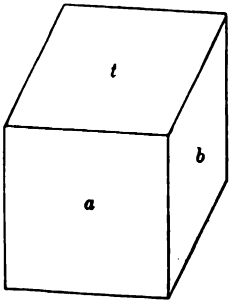

Figure 13.—Crystal of rhombic habit, nearly equidimensional. Compare with figure 7, p. 57. Crystal No. 24. Forms: *b*{010}, *a*{100}, *t*{102}.

Habit 5. The rhombic crystals are very abundant on some specimens and other habits are then entirely absent. (See Pls. XI and XII.) The rhomboids consist of either a single crystal bounded by plane surfaces or of an agglomeration of innumerable crystals, each deviating a little more from strict parallelism with the first unit. The crystals are generally elongated parallel to the *c* axis, as shown in figure 7, though some of them are more nearly equidimensional, as shown in figure 13 (crystal No. 24). The characteristic combination is *b*{010}, *a*{100}, *t*{102}, and other forms are rare. Many of these rhombic crystals are fairly large, the longer diameter of *t*{102} in average individuals measuring nearly half a centimeter.

COMBINATIONS.

The combinations observed on the 38 crystals measured are shown in the following tables, wherein the different crystals have been grouped according to their habit, as the various habits have a markedly different combination. Thus the essential forms, that is, those which are characteristic for a certain habit, are given below for the five different habits observed. The forms are further grouped as prominent or not prominent, depending on whether or not they have a decided influence on the shape of the crystal. Forms that are not prominent are placed in parentheses.

Characteristic forms for each crystal habit.

Form.	1. Wedge-shaped.	2. Short prismatic.	3. Tabular.	4. Cubic.	5. Rhombic.
c{001}	*c*	*c*	*c*	*c*	
b{010}	(*b*)	*b*	(*b*)	*b*	*b*
a{100}	*a*	*a*	*a*	*a*	*a*
m{110}	*m*	(*m*)	(*m*)		
l{210}	*l*	*l*	(*l*)		(*l*)
f{011}	*f*	(*f*)			
t{102}		(*t*)		(*t*)	*t*
H{904}					(*H*)
s{112}	(*s*)	(*s*)		(*s*)	
ω{111}	(*ω*)	(*ω*)			

Combinations on crystals with wedge-shaped habit.

Form.	Crystal No.									
	2	4	8	29	30	31	32	33	34	35
c{001}	*c*	*c*	*c*	*c*	*c*	*c*	*c*	*c*	*c*	*c*
b{010}	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*	*b*
a{100}	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*	*a*
m{110}	*m*	*m*	*m*	*m*	*m*	*m*	*m*	*m*	*m*	*m*
l{210}	*l*	*l*	*l*	*l*	*l*	*l*	*l*	*l*	*l*	*l*
R{15.7.0}						*R*				
C{940}						*C*				
n{810}							*n*			
f{011}	*f*	*f*	*f*				*f*	*f*	*f*	*f*
H{904}						*H*			*H*	
r{$\bar{1}$.0.11}										*r*
ω{111}			*ω*			*ω*	*ω*	*ω*	*ω*	*ω*
p{214}				*p*	*p*					
s{112}							*s*	*s*		
o{$\bar{1}$11}								*o*	*o*	*o*

Combinations on crystals with short prismatic habit.

Form.	Crystal No.															
	1	3	5	6	7	9	13	14	15	16	17	18	19	20	21	22
c{001}	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c
b{010}	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
a{100}	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a
m{110}	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m	m
l{210}	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l	l
r{120}	r	r	r	r	r	r	r									
R{15.7.0}												R				
C{940}	C											C				
F{520}	F															F
Q{830}												Q				
d{310}						d										
G{720}								G								
M{510}	M						M	M								
N{11.2.0}								N			N					
j{610}						j					j					
L{710}			L					L								
n{810}			n				n	n			n					
f{011}	f	f	f	f	f	f	f		f		f		f	f	f	f
u{104}							u									
t{102}						t	t	t	t	t	t	t	t	t	t	t
H{904}							H	H	H	H			H	H		
T{1̄.0.11}				T		T										
B{123}							B						B			
E{5.9.14}													E	E	E	
ω{111}				ω		ω	ω		ω	ω			ω	ω		ω
Δ{112}							Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ
A{337}							A		A					A	A	
p{214}													p			
D{313}													D			
s{1̄21}								s								
e{1̄12}				e												
o{1̄11}				o	o	o		o			o					

Combinations on crystals with tabular habit.

Form.	Crystal No.					
	10	11	12	23	27	28
c{001}	c	c	c	c	c	c
b{010}	b	b	b	b	b	b
a{100}	a	a	a	a	a	a
m{110}	m	m	m	m		
l{210}	l	l	l	l		
R{15.7.0}				R		
Q{830}				Q		
n{810}				n		
f{011}	f		f	f		
t{102}				t	t	t
H{904}					H	H
E{5.9.14}					E	

Combinations on crystals with cubic and rhombic habits.

Form.	Cubic habit.			Rhombic habit.		
	Crystal No.			Crystal No.		
	36	37	38	24	25	26
c{001}	c	c	c			c
b{010}	b	b	b	b	b	b
a{100}	a	a	a	a	a	a
l{210}			l	l	l	
t{102}	t	t	t	t	t	t
H{904}				H	H	H
Δ{112}	Δ	Δ	Δ			

TWINNING.

Twin crystals were often observed. Only one twinning law was noticed, namely, with {023} as the twinning plane. The many groupings parallel to *a*{100} were carefully examined for evidences of twinning on the *a*(100) face, but none were seen. As these parallel groupings generally have the *t*(102) face well developed, twinning on the *a*(100) face would cause a twinned face of *t*(102) to assume the position of $(\bar{1}02)$, and there would then be an apparent rear orthodome as well as a front one on such a twinned crystal. The absence of such a rear orthodome would indicate that these parallel groupings were not twinned.

Though only one twinning law was observed, namely {023}, there were two kinds of twins according to this law, namely, contact and penetration twins. Both were observed many times. though the contact twins are more abundant.

The contact twins are illustrated in figures 14 and 15, which show the twinned crystal facing in two directions, or in other words show the two positions a twinned group will take according to which face of {023} acts as twinning plane. Both positions of the twinned group have the same crystallographic relationship. The position shown in figure 14 shows the clinopinacoid *b*{010} of the twinned crystal adjoining the same form of the untwinned crystal. In figure 15 the basal pinacoid *c*{001} of the twinned crystal is shown. In the two illustrations the relationships of the contact twins are more clearly indicated than can be done by a written description.

The line of contact of the two crystals affords some points of interest, but for the present only a description of it is given. Theoretically it should be a straight line, as drawn in figures 14 and 15, but actually it is very uneven, the two parts of the twinned crystal being very irregularly dovetailed, as illustrated diagrammatically in figure 16, which was drawn from a twinned crystal (notebook No. A13), as seen on the goniometer.

In the penetration twins the containing unit is always much larger than the one which is partly embedded and projects out of the middle of the larger crystal, as shown in figure 17. The two crystals, though of different appearance, have the same combination of crystal forms as those shown in figures 14 and 15. Similarly figure 18 shows the same kind of penetration twin with the smaller twinned crystal in the opposite direction to that in figure 17. The large untwinned crystal in figure 18 is shown with one end cleaved off, due to the clinopinacoidal cleavage *b*(010). (See Pl. VIII, *A*, p. 19.)

The angle *c*(001):$\underline{b}$(010) (fig. 17) is 29° 58′, and the angle *c*(001):$\underline{c}$(001) (fig. 18) is 60° 02′. These angular values are here given as reference will be made to them later and the position of the faces forming the angles can here well be seen.

A peculiarity noted by Mr. Hess on several crystals similar to the one shown in figure 18 is that in front of the twinned crystal, on the larger untwinned unit, is a small cavity bounded by rough planes which

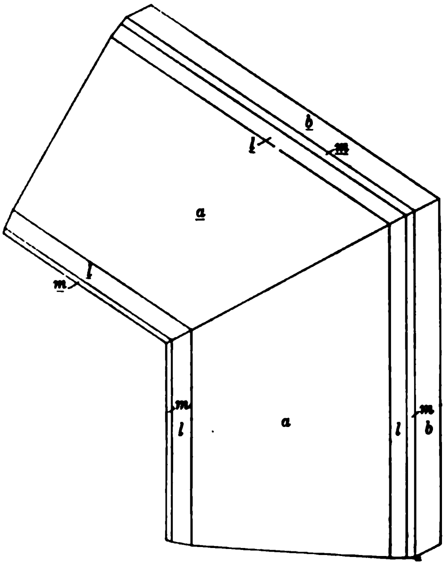

Figure 14.—Contact twin on (0$\bar{2}$3). Forms: *b*{010}, *a*{100}, *m*{110}, *l*{210}.

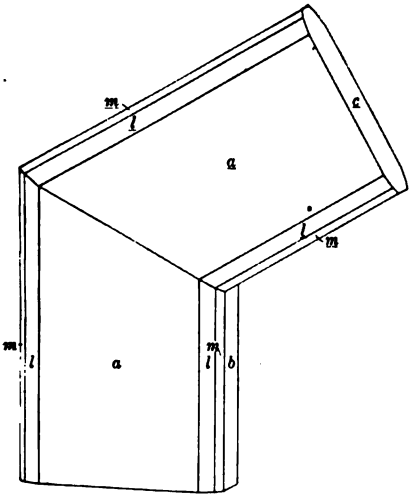

Figure 15.—Contact twin on (023). Forms: *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}.

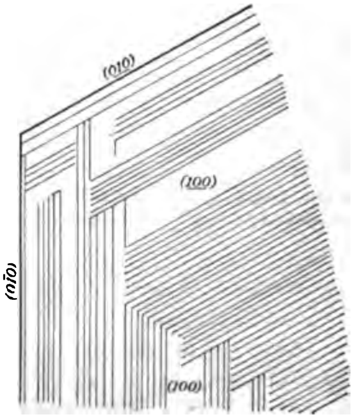

Figure 16.—Line of contact of two contact twins.

however suggest that they may be slightly developed terminal faces, such as *f*{011}. (See Pl. VIII, *A*, p. 19, center.) They may be caused, however, by crystals of scheelite, now removed.

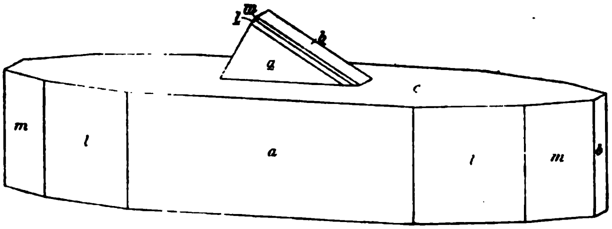

FIGURE 17.—Penetration twin on (0$\bar{2}$3). Forms: *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}.

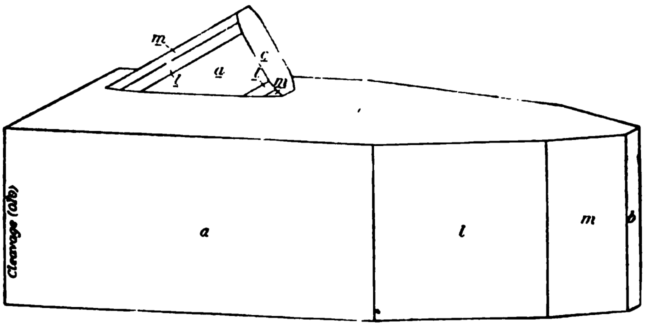

FIGURE 18.—Penetration twin on (023). Forms: *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}.

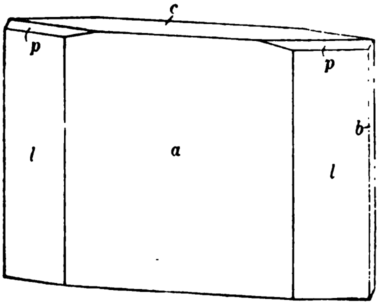

FIGURE 19.—Crystal 29, showing rare form *p*. Forms: *c*{001}, *b*{010}, *a*{100}, *l*{210}, *p*{214}.

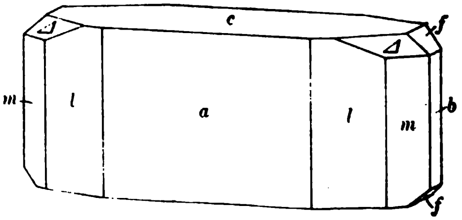

FIGURE 20.—Crystal 32. Forms: *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}, *f*{011}, *Δ*{112}.

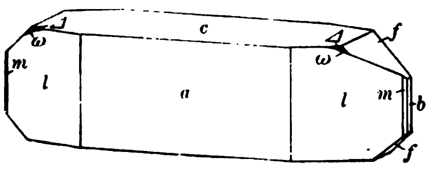

FIGURE 21.—Crystal 33. Wedge-shaped crystal with unequal development of the faces of *f*. Forms: *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}, *f*{011}, *Δ*{112}, *ω*{111}.

DESCRIPTION OF MEASURED CRYSTALS.

Only such crystals as are illustrated by drawings will be here mentioned. The general types of habit have already been shown under the section entitled "Habit," where drawings of a few of the measured crystals were also introduced. In general the following figures show the crystals in their ideal development. As most of them were bounded on one side by the cleavage face (0$\bar{1}$0) the exact dimension of the crystals in this direction could only be estimated, but by observing similar crystals that were intact it is believed that the proportions shown in the figures closely approximate the true relative dimensions. The crystals illustrated will be grouped under the five habits.

Crystal 29 (fig. 19) is simple in its combination but shows the rare form *p*{214} fairly well developed. It is, moreover, except *c*{001}, the only terminal form on this crystal. Crystal No. 32 (fig. 20) shows a common combination for a number of minute stout crystals in which the wedge shape is not so characteristic as in crystal No. 33 (fig. 21). Here also the upper and lower faces of *f*{011} are unequally developed. With the large development of *l*{210} the pyramid faces generally become smaller.

Crystal 5 (fig. 22) is remarkable in possessing such a small orthopinacoid, *a*{100}, the large faces of *n*{810} seeming to replace the usually large faces of *a*. Crystals 6 (fig. 23) and 9 (fig. 24) are both shown in their actual condition, with one side bounded by the cleavage face (0$\bar{1}$0). Both of them show a line face of the rare negative dome *γ*{$\bar{1}$.0.11} and figure 24 also shows the large positive dome *t*{102}. The rare prism *d*{310} is shown as a line face, and a face of *j*{610}, though not shown, is also present. Crystal 13 (fig. 25) shows a number of new and rare forms, all as narrow faces, generally mere line faces, except one form which is present as a minute equidimensional face. The new forms *H*{904}, *A*{337}, *B*{123}, and the rare forms *n*{810} and *u*{104} are the ones referred to. The clinodome, *f*{011}, is much narrower and longer than is usual for the faces of this form. Crystal 16 (fig. 26) gives a combination seen on numerous crystals not measured. The new form *H*{904} is generally present on such crystals. Crystal 17 (fig. 27) shows *j*{610}, *n*{810}, and *o*{$\bar{1}$11} besides the more common forms. Crystal 18 (fig. 28) shows the striations observed on *Δ*{112}, these striæ being parallel to the intersection edges (112) : (001) and (112) : ($\bar{2}$10), respectively. The crystal is also more elongated in a vertical direction than is usual. Crystal 19 (fig. 29) shows a number of new pyramids, namely, *D*{313}, *B*{123}, *E*{5.9.14}, and the rare pyramid *p*{214}. The zonal relationships of *Δ*(112), *E*(5.9.14), *B*(123), *f*(011), and *m′*($\bar{1}$10) could be well seen on this crystal. Crystal 20 (fig. 30) also shows the new form *E*{5.9.14}, as well as *A*{337} and *H*{904}.

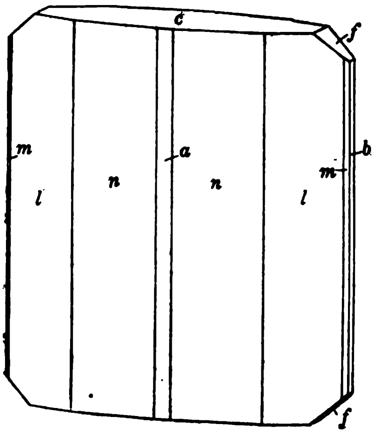

FIGURE 22.—Crystal 5, remarkable for its small orthopinacoid *a*{100}. Forms: *c*{100}, *b*{010}, *a*{100}, *m*{110}, *l*{210}, *n*{810}, *f*{011}.

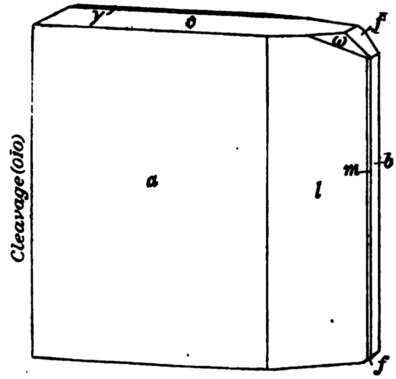

FIGURE 23.—Crystal 6, with rare form *γ*. Forms: *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}, *f*{011}, *γ*{$\bar{1}$.0.11}, *ω*{111}.

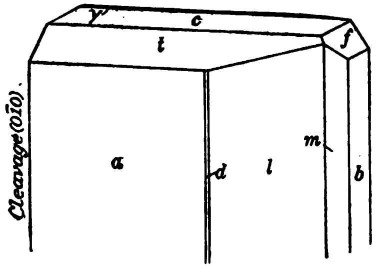

FIGURE 24.—Crystal 9, with rare forms *γ* and *d*. Forms: *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}, *d*{310}, *f*{011}, *t*{102}, *γ*{$\bar{1}$.0.11}. The form *j*{610}, not shown in the figure, is also present on this crystal.

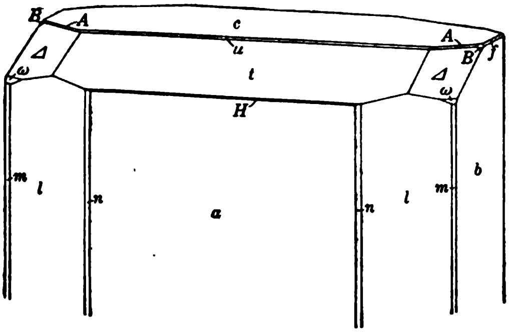

FIGURE 25.—Crystal 13, showing the new forms *A*, *B*, and *H* and the rare forms *n* and *u*. Forms: *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}, *n*{810}, *f*{011}, *u*{104}, *t*{102}, *H*{904}, *Δ*{337}, *A*{112}, *ω*{111}, *B*{123}.

Crystal 36 (fig. 31) shows a cubic crystal somewhat elongated in the vertical direction. The form *t*{102} is invariably present on these crystals, as is also generally *Δ*{112}. Figure 32 illustrates a cubic crystal apparently slightly elongated in the direction of the *a* axis, but in reality the original crystal was elongated parallel to the *b* axis, as the crystal shown in the drawing is incomplete, part of

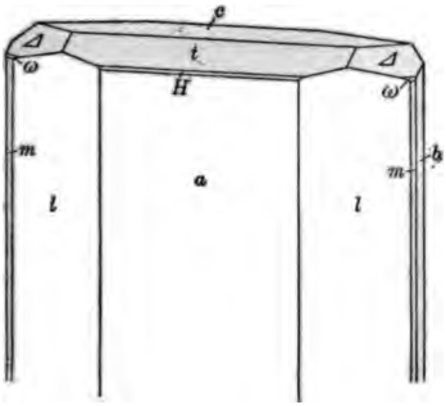

FIGURE 26.—Crystal 16, a combination observed on many crystals not measured. Forms: *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}, *t*{102}, *H*{904}, *Δ*{112}, *ω*{111}.

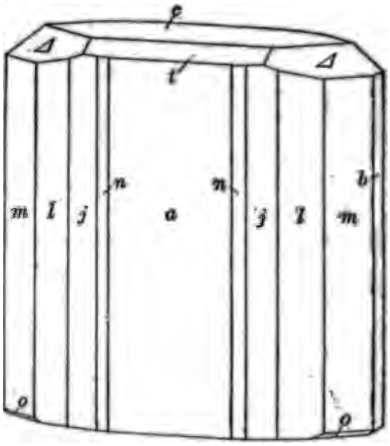

FIGURE 27.—Crystal 17, showing rare forms *n*, *j*, and *o*. Forms: *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}, *j*{610}, *n*{810}, *t*{102}, *Δ*{112}, $o\{\bar{1}11\}$.

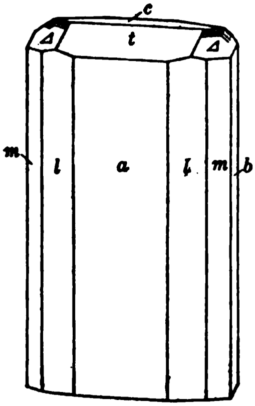

FIGURE 28.—Crystal 18, showing striations on *Δ*. Forms: *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}, *t*{102}, *Δ*{112}.

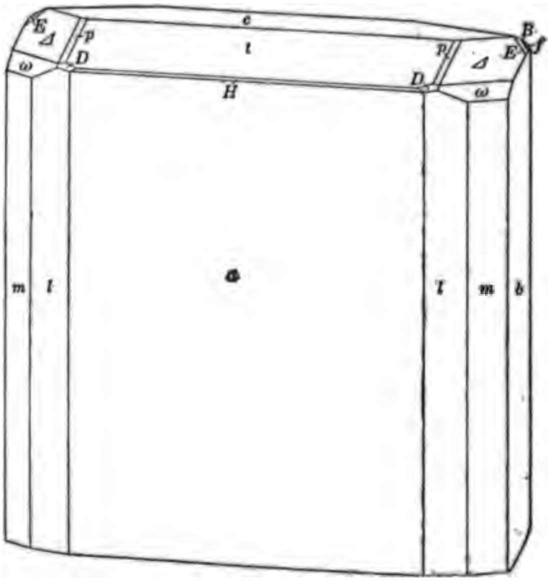

FIGURE 29.—Crystal 19, showing new forms *D*, *B*, and *E*. The zone *Δ*{112}, *E*{5.9.14}, *B*{123}, *f*{011}, and $m'\{\bar{1}10\}$ is well shown. Other forms are *c*{001}, *b*{010}, *a*{100}, *m*{110}, *l*{210}, *t*{102}, *H*{904}, *ω*{111}, *p*{214}, *D*{313}.

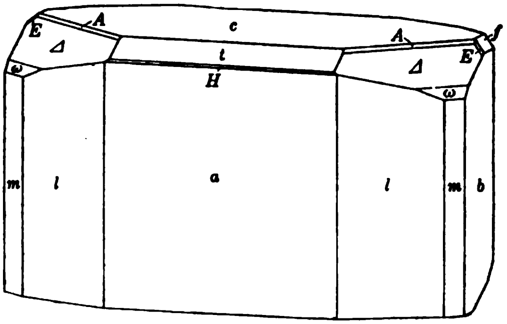

FIGURE 30.—Crystal 20, with new forms H, A, and E. Forms: $c\{001\}$, $b\{010\}$, $a\{100\}$, $m\{110\}$, $l\{210\}$, $f\{011\}$, $t\{102\}$, $H\{904\}$, $A\{337\}$, $\Delta\{112\}$, $\omega\{111\}$, $E\{5.9.14\}$.

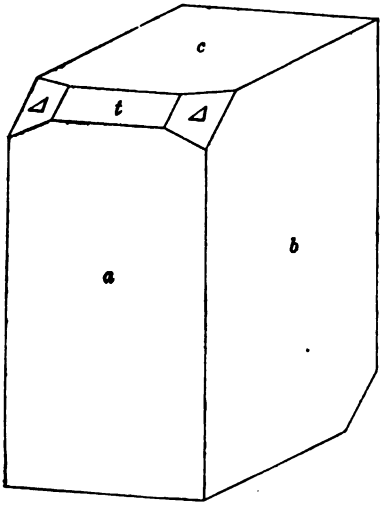

FIGURE 31.—Crystal 36, a cubic crystal, somewhat elongated parallel to its vertical axis. Forms: $c\{001\}$, $b\{010\}$, $a\{100\}$, $t\{102\}$, $\Delta\{112\}$.

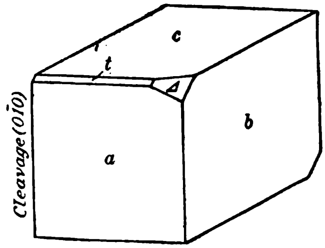

FIGURE 32.—Cubic crystal (No. 37), apparently elongated parallel to a axis, but in reality elongated parallel to b axis, the left-hand side of the crystal having cleaved off.

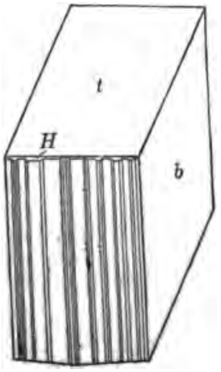

FIGURE 33.—Rhombic crystal (No. 25), with the broad orthopinacoid replaced by numerous narrow alternating faces of $a\{100\}$ and $l\{210\}$.

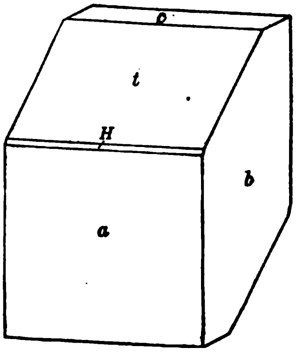

FIGURE 34.—Crystal 26, a rhombic crystal. Forms: $c\{001\}$, $b\{010\}$, $a\{100\}$, $t\{102\}$, $H\{904\}$.

it having cleaved off. The face of *t*{102} is much narrower than that on figure 31.

Crystal 25 (fig. 33) shows a rhombic crystal similar to those shown in figures 7 and 13 (pp. 57, 59), with the broad orthopinacoid *a*{100}, replaced by numerous narrow alternating faces of *a*{100} and *l*{210}, those of *l*{210} being much narrower than those of *a*{100}. The form *H*{904} is also present. The drawing is, however, but a poor representation of the true appearance of the crystal. Crystal No. 26 (fig. 34) shows the rhombic combination, *a*, *b*, *t*, modified by *c*{001} and *H*{904}.

FORM SYSTEM OF THE WOLFRAMITE GROUP.

CRITICAL STUDY OF FORMS.

Before the monoclinic character of wolframite was determined it was considered as orthorhombic, and it is therefore not possible to tell which are the negative and which are the positive forms in the earlier descriptions. The list of forms is fairly extensive, a total of 49 being recorded. Some of these forms will be briefly commented on, as follows:

S{7.11.0} was described by Warren as new and the letter *i* assigned to it. As, however, *i* had already been preempted by the form {$\bar{4}$03}, the letter *S* is assigned to the form {7.11.0}. The measured angle is given as follows: (7.11.0): ($\bar{7}$.11.0) = 74° 51′. The calculated value is 75° 16′ and the calculated value for the simpler form {580} is 74° 16′. The differences between the angles measured and the values calculated are, for {7.11.0} 0° 25′ and for {580} 0° 35′. Although the difference is slightly less for the more complex symbol, the agreement is far from satisfactory. The correct symbol of the form is therefore in doubt, and, though the indices would seem to be possibly simpler than {7.11.0}, these indices are inserted in the table of forms, but are marked with a (?) to indicate that the symbols need verification. (See also p. 55.)

w{021} was noted only by Descloizeaux and by Jeremejew. Attention is called to the fact that {021} occupies almost exactly the same position as *c*{001} in twin position. It is therefore possible that a face of *c*{001} in twin position (as shown in fig. 35) was measured and taken for (021).

c(001) : *w*(021) = 60° 01′ (calculated).
c(001) : $\underline{c}$(001) = 60° 02′ (calculated; p. 62

The difference between the two values is so small as to be unmeasurable. It seems right, therefore, to regard the form *w*{021} as doubtful and as at least needing verification before it can be accepted as a definite form.

g{095}, found only by Descloizeaux, also needs verification. The measured angle agrees much better with the slightly more complex form {0.11.6}.

(011) : (095) =16° 47′ (measured by Descloizeaux).
(011) : (095) =16° 26′ (calculated); difference =+21′.
(011) : (0.11.6)=16° 54′ (calculated); difference =−07′.

The form is therefore considered doubtful, on account of the uncertainty of its symbol and because it needs verification.

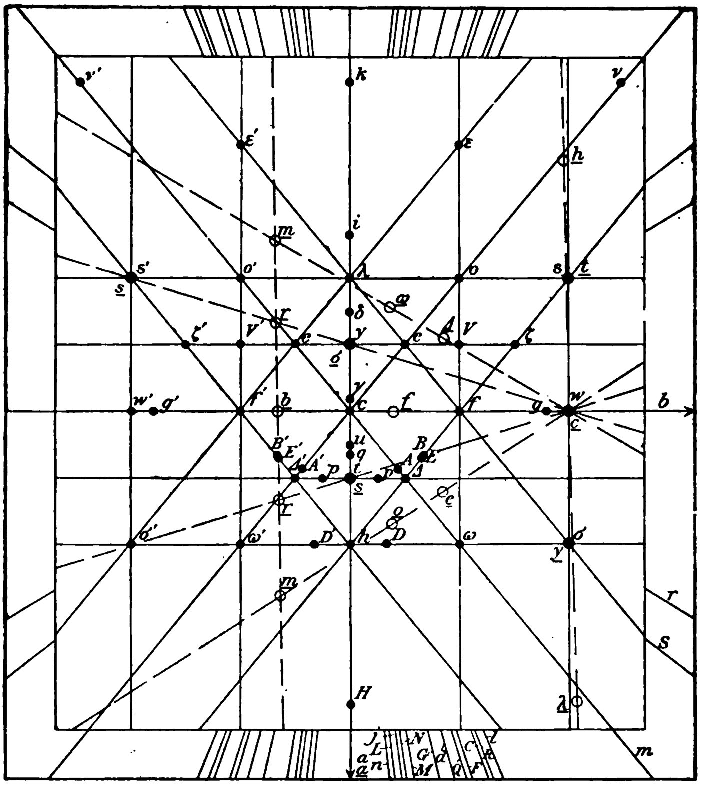

Figure 35.—Gnomonic projection of forms of the wolframite group. Several forms are plotted in twin position (open circle) to show their close position to untwinned forms. Thus note particularly $\underline{c}$ and *w*, $\underline{s}$ and *t*, $\underline{y}$ and *σ*, $\underline{t}$ and *s*, $\underline{s}$ and *s*, $\underline{\Delta}$ and *V*.

δ$\{\bar{3}04\}$, described only by Groth and Arzruni, is also doubtful, as the measured angles vary considerably from the values calculated for them.

Angles for the form δ$\{\bar{3}04\}$.

Angle.	Measured.	Calculated.	Difference.
	° ′	° ′	° ′
(001) : $(\bar{3}04)$........	39 56	38 23	+1 33
$(\bar{1}02)$: $(\bar{3}04)$........	11 51	10 36	+1 15
$(\bar{3}04)$: $(\bar{1}01)$........	9 17	8 15	+1 02

$\lambda\{\bar{1}01\}$, described first by Groth and Arzruni and later noted by Groth (but without measurement), is also doubtful. (001) : ($\bar{1}$01) = 48° 37′ measured and 46° 38′ calculated, the difference being 1° 59′.

$z\{113\}$ given by Miller[1] has always been considered a questionable form. Though inserted by Goldschmidt in his Winkeltabellen with a query, it had best be omitted. The symbol may be a misprint for {112}.

Eakle gives the letter *v* to a new form $\{\bar{1}22\}$ on wolframite from Nevada, but as the letter *v* is already preempted by the form $\{\bar{5}52\}$, Eakle's letter is changed to *V*. Eakle's letter *h* should be changed to *d* and *d* changed to *ε*.

It may be noted, too, that the correctness of the positive or negative character of several of the forms listed is very questionable. This is particularly true of the domes described by Krenner, who himself called attention to this uncertainty.

Figure 35 shows the gnomonic projection of all the known forms of the wolframite series except $\tau\{321\}$, which falls outside of the projection, and $x\{754\}$, which was described after the gnomonic projection was drawn and reproduced. The position of the forms is indicated in figure 35 by dots, whereas the position of some of the forms in twin position (twinned on {023}) is shown by open circles.

All the forms lie in well-developed zones. The prism zone is the richest, containing a total of 17 forms, but hardly any of the simple zones are poor in forms.

The position of many of the twinned forms is nearly identical with other forms which are not twinned and which are in their normal position, as, for example, $\underline{y}\{\bar{1}02\}$ and $\sigma\{121\}$, $\underline{c}\{001\}$ and $w\{021\}$, $\underline{t}\{102\}$ and $s\{\bar{1}21\}$, $\underline{s}\{\bar{1}21\}$ and $t\{102\}$, $\underline{\sigma}\{121\}$ and $y\{\bar{1}02\}$, $\underline{s}\{\bar{1}21\}$ and $s\{\bar{1}21\}$.

FORMS AND COORDINATE ANGLES.

The following table of forms and coordinate angles shows several points to which attention may be called. If a form is considered doubtful—that is, if it seems uncertain whether such a form actually exists—the question mark used to indicate this is placed with and immediately following the letter of the form. Thus *w* ?{021} means that there is doubt as to whether such a form has actually been found. If, on the other hand, there is no question about the existence of the form, but the symbols seem to be incorrectly determined, or at least a verification of the correctness of the measurement is desired, the question mark is placed after the symbols, thus *S*{7.11.0} ?.

References are given when the form has been seen and described by only one observer or two independent observers. If at least three different observers have noted the form its confirmation would seem to be so well established that references to it are in general not necessary. The occurrence of the form on the three members of the wolframite group has also been noted.

---

[1] Miller, W. H., Elementary introduction to mineralogy, p. 473, 1852.

Forms and coordinate angles, wolframite group.

[$a=0.8255$; $c=0.8664$; $\beta=89°\ 32'$.]

No.	Letter.	Symbol.		ϕ	ρ	References.[a]	Ferberite, $FeWO_4$.	Wolframite, $(Fe, Mn)WO_4$.	Hübnerite, $MnWO_4$.
		Goldschmidt.	Miller.	° ′	° ′				
1	*c*	0	001	90 00	0 28	....	*c*	*c*	*c*
2	*b*	0 ∞	010	0 00	90 00	....	*b*	*b*	*b*
3	*a*	∞ 0	100	90 00	90 00	....	*a*	*a*	*a*
4	*r*	∞ 2	120	31 12	90 00	....	*r*	*r*	....
5	*S*	∞ $\frac{11}{7}$	7.11.0?	37 38	90 00	....	*S*	....	....
6	*m*	∞	110	50 27	90 00	....	*m*	*m*	*m*
7	*l*	2 ∞	210	67 34	90 00	....	*l*	*l*	*l*
8	*R*	$\frac{15}{7}$ ∞	15.7.0	68 58	90 00	....	*R*	....	....
9	*C*	$\frac{9}{4}$ ∞	940	69 51	90 00	....	*C*	....	....
10	*F*	$\frac{5}{2}$ ∞	520	71 44	90 00	....	*F*	....	....
11	*Q*	$\frac{8}{3}$ ∞	830	72 48	90 00	....	*Q*	....	*Q*
12	*d*	3 ∞	310	74 37	90 00	....	*d*	*d*	*d*
13	*G*	$\frac{7}{2}$ ∞	720	76 44	90 00	....	*G*	....	....
14	*M*	5 ∞	510	80 38	90 00	....	*M*	....	....
15	*N*	$\frac{11}{2}$ ∞	11.2.0	81 28	90 00	....	*N*	....	....
16	*j*	6 ∞	610	82 10	90 00	12	*j*	....	....
17	*L*	7 ∞	710	83 16	90 00	13	*L*	....	....
18	*n*	8 ∞	810	84 06	90 00	4, 13	*n*	*n*	....
19	*w?*	0 2	021	0 16	60 00	2, 3	....	*w*	....
20	*g?*	0 $\frac{9}{5}$	095	0 18	57 20	2	....	*g*	....
21	*f*	0 1	011	0 32	40 54	....	*f*	*f*	*f*
22	*γ*	$-\frac{1}{11}$ 0	$\bar{1}$.0.11	90 00	4 59	4, 13	*γ*	*γ*	....
23	*u*	$+\frac{1}{4}$ 0	104	90 00	15 08	3, 13	*u*	*u*	....
24	*q*	$+\frac{1}{3}$ 0	103	90 00	19 41	3	....	*q*	....
25	*y*	$-\frac{1}{2}$ 0	$\bar{1}02$	90 00	27 19	....	*y*	*y*	....
26	*t*	$+\frac{1}{2}$ 0	102	90 00	28 03	....	*t*	*t*	*t*
27	*δ?*	$-\frac{3}{4}$ 0	$\bar{3}04$	90 00	37 55	4	....	*δ*	....
28	*λ?*	−10	$\bar{1}01$	90 00	46 10	4, 6	....	*λ*	....
29	*h*	+10	101	90 00	46 36	5, 6	....	*h*	....
30	*i*	$-\frac{4}{3}$ 0	$\bar{4}03$	90 00	54 17	5	....	*i*	....
31	*H*	$+\frac{9}{4}$	904	90 00	67 07	13	*H*	....	....
32	*k*	$-\frac{5}{2}$ 0	$\bar{5}02$	90 00	69 04	5	....	*k*	....
33	*ζ*	$-\frac{1}{2}\,\frac{3}{2}$	$\bar{1}32$	21 41	54 26	5	....	*ζ*	....
34	*V*	$-\frac{1}{2}$ 1	$\bar{1}22$	30 48	45 15	18	....	*V*	....
35	*s*	−12	$\bar{1}21$	31 00	63 41	....	*s*	*s*	....
36	*σ*	+12	121	31 24	63 46	....	....	*σ*	....
37	*B*	$+\frac{1}{3}\,\frac{2}{3}$	123	31 47	34 12	13	*B*	....	....
38	*E*	$+\frac{5}{14}\,\frac{9}{14}$	5.9.14	34 31	34 03	13	*E*	....	....
39	*D*	$+1\,\frac{1}{3}$	313	47 21	74 44	13	*D*	....	....
40	*e*	$-\frac{1}{2}$	$\bar{1}12$	50 01	33 59	....	*e*	*e*	....
41	*o*	−1	$\bar{1}11$	50 14	53 34	....	*o*	*o*	....
42	*v*	$-\frac{5}{2}$	$\bar{5}52$	50 22	73 35	5	....	*r*	....
43	*ω*	+1	111	50 40	53 49	....	*ω*	*ω*	*ω*
44	*Δ*	$+\frac{1}{2}$	112	50 53	34 29	....	*Δ*	....	*Δ*
45	*A*	$+\frac{3}{7}$	337	50 58	30 31	13	*A*	....	....
46	*x*	$+\frac{7}{4}\,\frac{5}{4}$	754	59 35	64 57	....	....	....	*x*
47	*τ*	+32	321	61 14	74 29	7	....	....	*τ*
48	*ι*	−21	$\bar{2}11$	67 29	66 10	....	....	*ι*	....
49	*p*	$+\frac{1}{2}\,\frac{1}{4}$	214	67 53	29 55	11, 13	*p*	....	....

[a] Numbers refer to the Bibliography, pp. 74–75.

COMBINATIONS OBSERVED ON THE WOLFRAMITE GROUP.

The following table shows the combinations described on minerals of the wolframite group commencing with the definite establishment of the monoclinic character of the group by Descloizeaux in 1850. As wolframite was considered to be orthorhombic in the earlier descriptions, the combinations of those writers are not given, as the positive and negative forms can not be differentiated. Numbers after names of authors refer to similar numbers in the bibliography.

Combination No. 10 gives the entire list of forms mentioned by Descloizeaux and doubtless represents several crystals, in part probably the same as combinations Nos. 1, 2, and 3. Combination 11 likewise gives the complete list of forms observed by Jeremejew, as I was not able to decipher the individual combinations from the Russian text.

Combinations described on crystals of minerals of the wolframite group.

No.	Combination.	Mineral.	Locality.	Author.	Date.
1	*bamlfoω*	Wolframite	Chanteloube	Descloizeaux (1)	1850
2	*amlfoω*	do	do	do. (1)	1850
3	*amlfgyt*	do	do	do. (1)	1850
4	*cbamlfyt*	do	Altenberg	do. (1)	1850
5	*camlfκoω*	do	do	do. (1)	1850
6	*amlfyts*	do	Zinnwald	do. (1)	1850
7	*amlfytso*	do	do	do. (1)	1850
8	*armlfyts*	do	do	do. (1)	1850
9	*bamtoε*	do	Schlaggenwald	do. (2)	1870
10	*cbarmlwgfytsσoω*	do	Chanteloube	do. (2)	1870
11	*cbarmlwfuqytsσoω*	do	Altai, Russia	Jeremejew (3)	1872
12	*cbamnryελωε*	do	Schlaggenwald	Groth and Arzruni (4).	1873
13	*bak*	do	Felsobanya	Krenner (5)	1875
14	*baik*	do	do	do. (5)	1875
15	*badik*	do	do	do. (5)	1875
16	*cbd*	do	do	do. (5)	1875
17	*bat*	do	do	do. (5)	1875
18	*bayh*	do	do	do. (5)	1875
19	*bay*	do	do	do. (5)	1875
20	*bhv*	do	do	do. (5)	1875
21	*batv*	do	do	do. (5)	1875
22	*cbadyikζe*	do	do	do. (5)	1875
23	*cafhε*	do	Altenberg	Groth (6)	1878
24	*amlλhεω*	do	Zinnwald	do. (6)	1878
25	*bam*	Hübnerite	Pyrenees	Bertrand (7)	1882
26	*cbamlfysσεoωτκ*	Wolframite	Spain	Seligman (8)	1886
27	*amfy*	do	Fichtelgebirge	Sandberger (9)	1888
28	*b(a)mQftω*	Hübnerite	Silverton, Colo	Penfield (10)	1892
29	*b(a)mQt*	do	New Mexico	do. (10)	1892
30	*b(a)mQtΔ*	do	do	do. (10)	1892
31	*amlft*	Wolframite	Altai	Jeremejew (11)	1894
32	*amfo*	do	Japan	Jimbo (12)	1899
33	*cbaSmlfytΔ*	Ferberite	South Dakota (Colorado?).	Warren (13)	1901
34	*camlfytsσoω*	Wolframite	New South Wales.	Anderson (14)	1904
35	*cb(a)mltΔp*	Ferberite	Boulder County, Colo.	Moses (15)	1905
36	*cbamdjfyteoωΔ*	do	Greenland	Bøggild (16)	1905
37	*cbamlftoω*	Wolframite	Bolivia	Spencer (17)	1907
38	*cbarmqdsεoe V*	do.[a]	Nevada	Eakle (18)	1912
39	*cbamldtx*	Hübnerite	Peru	Tronquoy (19)	1913

---

[a] Eakle states that "All of the material contains iron and is to be classed as wolframite rather than as hubnerite." His next sentence, "The crystals are tabular parallel to the orthopinacoid and some of them are exceedingly thin and almost transparent, with a deep-red color," would indicate, however, that the material was more likely hübnerite than wolframite.

The following combinations were observed by the writer on the ferberite from Colorado described in this report:

cbamlf
cbamlf
cbamlfω
cbamlp
cbamlp
cbamlRCHω
cbamlfω
cbamlfωpo
cbamlfHωo
cbamlfγωo
cbamlr CFMf
cbamlf
cbamlLnf

cbamlfγωeo
cbamlfo
cbamldjftγωo
cbamlMnfutHBωΔA
cbamlGMNLntHΔso
cbamlftHωΔA
cbamltHωΔ
cbamlNnftΔo
cbamlR CQtΔ
cbamlftHB EωΔpD
cbamlftHωΔA
cbamlftEΔA
cbaml FftωΔ

cbamlf
cbaml
cbamlf
cbamlRQnft
cbatHE
cbatH
cbatΔ
cbat
cbaltΔ
baltH
baltH
cbatH

By calculating the percentage occurrence for the 77 combinations listed (the 39 given in the table and the 38 observed by the writer), the forms of the wolframite group fall into three classes, as follows:

(1) Prominent forms:

Letter	a	b	m	c	l	f	t
Symbol	(100)	(010)	(110)	(001)	(210)	(011)	(102)
Per cent of occurrence	97	84	75	67	67	57	51

(2) Less prominent forms:

Letter	ω	o	Δ	y	H	s	o
Symbol	(111)	$(\bar{1}11)$	(112)	$(\bar{1}02)$	(904)	$(\bar{1}21)$	(121)
Per cent of occurrence	35	24	21	21	17	12	11

(3) Rare forms: All the remaining forms, 35 in number.

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BIBLIOGRAPHY
OF
NORTH AMERICAN GEOLOGY
FOR
1913
WITH SUBJECT INDEX

BY

JOHN M. NICKLES

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BIBLIOGRAPHY OF NORTH AMERICAN GEOLOGY FOR 1913, WITH SUBJECT INDEX.

By John M. Nickles.

INTRODUCTION.

The bibliography of North American geology, including paleontology, petrology, and mineralogy, for the year 1913 follows the plan and arrangement of its immediate predecessors, the bibliographies for 1906–7, 1908, 1909, 1910, 1911, and 1912 (Bulletins 372, 409, 444, 495, 524, and 545 of the U. S. Geological Survey). It includes publications bearing on the geology of the Continent of North America and adjoining islands, also Panama and the Hawaiian Islands. Papers by American writers on the geology of other parts of the world are not included. Textbooks and papers general in character by American authors are included; those by foreign authors are excluded unless they appear in American publications.

As heretofore, the papers, with full title and medium of publication and explanatory note when the title is not fully self-explanatory, are listed under the authors, arranged in alphabetic order. The author list is followed by an index to the literature listed. In this index the entries in one alphabet are of three kinds—first, subject, with various subdivisions, to enable the specialist to ascertain readily all the papers bearing on a particular subject or area; second, titles of papers, many of them abbreviated or inverted, under their leading words; and third, cross references, which have been freely used to avoid too much repetition. The subjects have been printed in black-faced type, the titles of papers and cross references in ordinary type. As it may not be always obvious which subject headings have been adopted, a classified scheme of those used immediately precedes the index.

Miss Isabel P. Evans has given efficient assistance in the work.

The bibliography of North American geology is comprised in the following bulletins of the United States Geological Survey: No. 127 (1732–1892); Nos. 188 and 189 (1892–1900); No. 301 (1901–1905); No. 372 (1906–7); No. 409 (1908); No. 444 (1909); No. 495 (1910); No. 524 (1911); No. 545 (1912); and No. 584 (1913).

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1204. The Sangamon interglacial stage in Minnesota and westward: Intern. Geol. Cong., Twelfth, Canada, 11 pp., 1913 (advance copy).

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CLASSIFIED SCHEME OF SUBJECT HEADINGS.

1. GENERAL.

Associations, meetings; Addresses; History; Philosophy; Biography; Bibliography; Educational; Text-books.

Classification; Nomenclature; Cartography; Technique; Field work; Surveys; Borings.

Geochemistry; Chemical analyses (list); Atmosphere; Radioactivity.

Experimental investigations; Miscellaneous.

2. REGIONAL.

The States of the Union, Alabama, etc.; the Provinces of Canada, Alberta, etc.; Greenland; Mexico; the countries of Central America; the West Indies, and the single islands; the Hawaiian Islands.

3. ECONOMIC.

Ore deposits, origin; Contact phenomena.

Gold; Placers; Black sands; Silver; Quicksilver; Nickel; Cobalt; Copper; Lead; Zinc; Iron; Magnetite; Manganese; Tin; Aluminum; Bauxite; Antimony; Bismuth; Tungsten; Wolframite; Vanadium; Uranium; Carnotite ores; Molybdenum; Molybdenite; Titanium; Rutile; Platinum; Iridium; Rhodium; Palladium; Cadmium; Monazite; Rare earths; Tantalum; Selenium; Tellurium; Zircon.

Coal; Anthracite; Coke; Peat; Lignite; Bituminous rock; Natural gas; Petroleum; Oil shales; Asphalt; Albertite; Gilsonite; Grahamite; Ozokerite.

Stone; Building stone; Granite; Bluestone; Limestone; Lime; Marble; Onyx; Sandstone; Clay; Kaolin; Bentonite; Fire clay; Ganister; Slate; Shale; Marl; Sand; Glass sand; Sand-lime brick; Gravel; Cement and cement materials; Concrete materials; Road materials; Trap; Steatite; Soapstone; Talc; Serpentine.

Precious stones; Diamonds; Sapphires; Turquoise; Tourmaline.

Abrasive materials; Corundum; Emery; Garnet; Diatomaceous earth; Tripoli; Volcanic ash; Millstones; Novaculite.

Asbestos; Feldspar; Mica; Quartz; Gypsum; Graphite; Fuller's earth; Infusorial earth; Magnesite; Mineral paint; Chromium; Chromite; Chromic iron ore; Fluorspar; Barite; Barytes; Strontium; Arsenic; Pyrite; Sulphur; Sulphate of soda; Cryolite; Phosphorus; Phosphate; Apatite; Potash; Alunite; Glauconite; Borax; Bromine; Salt; Natron deposits.

4. DYNAMIC AND STRUCTURAL.

Earth, genesis of; Earth, age of; Earth, interior of; Earth, temperature of.

Volcanism; Volcanoes; Earthquakes; Seismology; Seismographs; Mud volcanoes.

Isostasy; Orogeny; Changes of level.

Magmas; Intrusions; Dikes; Laccoliths; Metamorphism; Contact phenomena.

Deformation; Folding; Faulting; Unconformities.

Conglomerates; Concretions; Stalactites; Jointing; Cleavage.

Sedimentation; Denudation; Erosion; Caves; Sink holes; Erratic bowlders; Weathering; Wind work; Dunes; Loess; Landslides.

Glaciers; Glacial erosion; Eskers; Kames; Moraines; Kettle holes.

Drainage changes.

5. PHYSIOGRAPHIC.

Geomorphy; Relief maps.

Valleys; Cirques; Deserts; Dunes; Deltas; Alluvial fans; Eskers; Kames; Mounds, natural; Natural bridges; Sink holes; Karsts.

Lakes; Swamps; Marshes; Everglades; Terraces; Beaches; Shore lines; Rivers; Meanders; Falls; Springs.

6. HISTORIC OR STRATIGRAPHIC.

Geologic history; Geologic time; Paleogeography; Paleogeographic maps; Paleoclimatology.

Geologic maps; Geologic formations described (list).

Pre-Cambrian; Paleozoic (undifferentiated); Cambrian; Ordovician; Silurian; Devonian; Carboniferous; Triassic; Jurassic; Cretaceous; Tertiary; Quaternary; Recent; Glacial geology; Glaciation; Glacial lakes; Ice ages.

7. PALEONTOLOGY.

Geographic distribution; Evolution; Restorations.

Vertebrata; Man, fossil; Mammalia; Aves; Reptilia; Amphibia; Pisces; Footprints, fossil.

Invertebrata; Arthropoda; Crustacea; Trilobita; Ostracoda; Insecta; Arachnida; Myriapoda.

Mollusca; Cephalopoda; Gastropoda; Pelecypoda.

Molluscoidea; Brachiopoda; Bryozoa; Vermes.

Echinodermata; Echinoidea; Asteroidea; Crinoidea; Crystoidea.

Cœlenterata; Anthozoa; Hydrozoa; Graptolites.

Protozoa; Spongida; Foraminifera.

Paleobotany; Diatoms.

Problematica.

8. PETROLOGY.

Rocks, origin; Rocks, structural features; Rocks described (list); Igneous and volcanic rocks; Rock-forming minerals; Lava; Oolite; Pebbles.

9. MINERALOGY.

Minerals described (list); Crystallography; Pseudomorphism; Paragenesis of minerals; Rock-forming minerals; Meteorites.

10. UNDERGROUND WATER.

Mine waters; Thermal waters; Geysers; Springs; Mineral waters.

11. SOILS.

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Acadian, Cambrian, Nova Scotia: Hyde, 543.

Adams Lake formation, pre-Cambrian, British Columbia: Daly, 279.

Admiralty epoch (glacial), Pleistocene, Washington: Bretz, 101.

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Aftonian beds, Pleistocene: Alden and Stebinger, 11.

Aftonian drift, Quaternary: Deeley, 304.

Agassiz series, Paleozoic, British Columbia: Bowen, 93.

Alachua clay, Pliocene, Florida: Matson and Sanford, 768.

Albert Canyon division, pre-Cambrian, British Columbia: Daly, 279.

Albert series, Carboniferous, New Brunswick: Young, 1347.

Albertan drift, Pleistocene, Canada: Alden and Stebinger, 11.
Albion moraine, Quaternary, New York: Kindle and Taylor, 619.
Albion sandstone, Silurian, New York: Kindle and Taylor, 619.
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Aldridge formation, pre-Cambrian, British Columbia: Schofield, 1020.
Alexandrian series, Silurian, Illinois and Missouri: Savage, 1007, 1008.
Algoman, pre-Cambrian, Lake Superior region: Lawson, 665.
Algoman granite, pre-Cambrian, Ontario: Uglow, 1183.
Algonkian, pre-Cambrian, Lake Superior region: Lawson, 665.
Allegany drift, Quaternary: Deeley, 304.
Allegheny formation, Pennsylvanian, Pennsylvania: Campbell *et al.*, 169.
Allegheny series, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.
Allison Creek formation, Cretaceous, Alberta: Leach, 666.
Alta shale, Cambrian, Utah: Hintze, 507.
Altyn formation, pre-Devonian, Montana and British Columbia: Daly, 278.
Alum Bluff formation, Oligocene, Florida: Matson and Sanford, 768; Sellards and Gunter, 1038.
Ames limestone, Carboniferous, Ohio: Condit, 251; Mark, 747.
Ames limestones, Carboniferous, West Virginia: Hennen and Reger, 479.
Ames limestone member, Pennsylvanian, Pennsylvania: Campbell *et al.*, 169.
Ames or crinoidal limestone, Carboniferous, West Virginia: Krebs and Teets, 640.
Ames shale, Carboniferous, West Virginia: Hennen and Reger, 479.
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Anarchist series, Washington, British Columbia: Daly, 278.
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Anderdon limestone, Devonian, Michigan: Nattress, 840.
Andrews schist, Cambrian, Georgia: La Forge and Phalen, 643.
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Annabelle shale, Carboniferous, West Virginia: Hennen and Reger, 479.
Apalachicola group, Oligocene, Florida: Matson and Sanford, 768; Sellards and Gunter, 1038.
Appekunny formation, Cambrian, pre-Devonian, Montana and British Columbia: Daly, 278.
Aquia formation, Eocene, Virginia: Sanford, 1004.
Arago formation, Eocene, Oregon: Arnold and Hannibal, 18.
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Banff (lower) limestone, Devonian, Alberta: Shimer, 1045.
Banff (lower) limestone, Mississippian, Alberta: Allan, 13.
Banff shales, Carboniferous, Alberta: Malcolm, 741.
Banff (lower) shale, Mississippian, Alberta: Allan, 13; Shimer, 1045.
Banff (upper) limestone, Pennsylvanian, Alberta: Allan, 13; Shimer, 1045.
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Bangor limestone, Carboniferous, Tennessee: Burchard, 135.
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Bayport formation, Carboniferous, Michigan: Gregory, 442.
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Bearpaw formation, Cretaceous, Alberta, Saskatchewan, Manitoba: Malcolm, 741.
Bearpaw shale, Cretaceous, Montana: Stebinger, 1105.
Beauharnois formation, Ordovician, Quebec, Ontario: Raymond, 952.
Beaver group, Carboniferous, West Virginia: Krebs and Teets, 640.
Beaver Mountain group, Cretaceous?: Daly, 278.
Beckwith formation, Cretaceous and Jurassic, Idaho: Schultz and Richards, 1030.
Becraft member, Devonian, Maryland: Swartz *et al.*, 1138.
Bedford formation, Devonian, Ohio: Prosser, 932.
Bedford formation, Mississippian, Ohio: Burroughs, 140.
Beech Hill Cove formation, Silurian, Nova Scotia: Twenhofel, 1172.
Beehive formation, Cambrian, Idaho and British Columbia: Daly, 278.
Beekmantown group, Ordovician, Quebec, Ontario: Raymond, 952.
Bellaire sandstone, Carboniferous, Ohio: Condit, 251.
Belly River, Cretaceous, Alberta: Dowling, 326.
Belly River formation, Cretaceous, Alberta, Saskatchewan: Malcolm, 741.
Belly River series, Cretaceous, Alberta: Dowling, 327.
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Belt series, pre-Cambrian, British Columbia and Alberta: Walcott, 1225.
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Benson limestone, Devonian, Utah: Hintze, 507.
Benton formation, Cretaceous, Alberta: Leach, 666; Malcolm, 741.
Benton formation, Cretaceous, Colorado: Grout *et al.*, 450.
Benton, Cretaceous, Manitoba, Saskatchewan: Dowling, 326.
Benton shale, Cretaceous, North Dakota: Leonard, 678.
Benwood limestone, Carboniferous, West Virginia: Hennen and Reger, 479.
Berea sandstone, Mississippian, Ohio: Burroughs, 140; Prosser, 932.
Bergman group, Cretaceous, Alaska: Smith, 1068.
Bertie limestone member, Silurian, New York: Kindle and Taylor, 619.
Bethany limestone, Iowa: Tilton, 1159.
Bighorn dolomite, Ordovician or Silurian, Wyoming: Blackwelder, 78.
Bighorn formation, Cretaceous, Alberta: Malcolm, 741.
Birch Creek schist, pre-Ordovician, Alaska: Maddren, 739; Prindle, 920, 930.
Birmingham shale, Carboniferous, Ohio: Condit, 251; Mark, 747.
Birmingham shale, Carboniferous, West Virginia: Krebs and Teets, 640.
Black River formation, Ordovician, Quebec, Ontario: Raymond, 952.
Black River group, Ordovician, Quebec, Ontario: Raymond, 952.
Black River limestones, Ordovician, Ontario: Foerste, 378.
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Blackstone shales, Cretaceous, Alberta: Malcolm, 741.
Blaine formation, Permian, Oklahoma: Snider, 1078.
Bloomington formation, Cambrian, Utah: Richardson, 975.
Bloomsburg red shale, Silurian, Pennsylvania: Grabau, 427.
Bloomsbury formation, Carboniferous, New Brunswick: Young, 1347.
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Bohio conglomerate, Oligocene?, Panama Canal Zone: MacDonald, 723, 726.
Bolivar fire clay, Carboniferous, West Virginia: Hennen and Reger, 479.
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Bone Valley gravel, Pliocene, Florida: Matson and Sanford, 768.
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Bosworth formation, Cambrian (Upper), British Columbia: Allan, 13.
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Bow River series, Cambrian, Alberta: Malcolm, 741.
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Brasstown schist, Cambrian, North Carolina, Georgia: La Forge and Phalen, 643.
Brazean formation, Cretaceous, Alberta: Malcolm, 741.
Brazer limestone, Mississippian, Utah: Richardson, 975.
Bretonian, Cambrian, Nova Scotia: Hyde, 543.
Bretonian, Cambrian and Ordovician, New Brunswick: Young, 1347.
Brigham quartzite, Cambrian, Utah: Hintze, 507; Richardson, 975.
Bristol limestone, Carboniferous, West Virginia: Hennen and Reger, 479.
Brooklyn formation, Carboniferous?, British Columbia: LeRoy, 680.

Brooklyn formation, Carboniferous and post-Carboniferous, British Columbia: LeRoy, 680.
Broughton series, pre-Cambrian?, Quebec: Harvie, 466.
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Brush Creek horizon, Carboniferous, Ohio: Condit, 251.
Brush Creek limestone, Carboniferous, Ohio: Mark, 747.
Brush Creek limestone, Carboniferous, West Virginia: Krebs and Teets, 640.
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Buffalo sandstone, Carboniferous, Ohio: Condit, 251.
Buffalo sandstone, Carboniferous, West Virginia: Hennen and Reger, 479.
Buffalo sandstone, Carboniferous, West Virginia: Krebs and Teets, 640.
Buffalo sandstone member, Pennsylvanian, Pennsylvania: Campbell *et al.*, 169.
Buffalo Hart moraine, Quaternary, Illinois: Shaw and Savage, 1042.
Burgess shale, Cambrian (Middle), Alberta, British Columbia: Allan, 13.
Burgoon sandstone member, Mississippian, Pennsylvania: Campbell *et al.*, 169.
Burton sandstone, Carboniferous, West Virginia: Hennen and Reger, 479.
Cabots Head beds, Silurian, Ontario: Grabau, 427.
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Caloosahatchee marl, Pliocene, Florida: Matson and Sanford, 768.
Calvert formation, Miocene, Virginia: Sanford, 1004.
Cambridge limestone, Carboniferous, Ohio: Condit, 251; Mark, 747.
Campbells Creek limestone, Carboniferous, West Virginia: Krebs and Teets, 640.
Canajoharie shale, Ordovician: Grabau, 427.
Canyon formation, Carboniferous, Texas: Gordon, 416.
Carbondale formation, Pennsylvanian, Illinois: Shaw and Savage, 1042.
Caribbean limestone, Pliocene, Panama Canal Zone: MacDonald, 723, 726.
Carlton moraine, Quaternary, New York: Kindle and Taylor, 619.
Carmack basalts, Tertiary or Pleistocene, British Columbia: Cairnes, 158.
Cascade gneissic batholith, Jurassic, Washington, British Columbia: Daly, 278.
Cassville plant shale, Carboniferous, West Virginia: Hennen and Reger, 479.
Castle Mountain group, Cambrian and Ordovician, Alberta: Malcolm, 741.
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Cataract formation, Ordovician, Ontario: Parks, 887, 888, 890.
Cataract formation, Silurian, New York and Ontario: Schuchert, 1023, 1025.
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Cat Head limestone, Ordovician, Manitoba: Dowling, 326; Malcolm, 741; Wallace, 1230.
Cathedral batholith, Tertiary, Washington, British Columbia: Daly, 278.
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Catoctin schist, pre-Cambrian, Virginia: Watson and Cline, 1244.
Catskill formation, Devonian, Maryland: Prosser and Swartz, 936; Swartz, 1137.
Catskill formation, Devonian, New York to Virginia: Barrell, 45.
Cattaraugus formation, New York, Pennsylvania: Barrell, 45.
Cayuga group, Silurian, New York: Kindle and Taylor, 619.
Cedar district formation, Cretaceous (Upper), British Columbia: Clapp, 199.
Cedar limestone, Devonian, Missouri, Iowa: Keyes, 604.
Cedar volcanic series, Oligocene, British Columbia: Camsell, 170.
Cedar Valley formation, Devonian, Iowa: Keyes, 610.
Chagrin formation, Devonian, Ohio: Prosser, 932.
Chalky Mount group, Barbados: Cunningham-Craig, 270.
Chancellor formation, Cambrian (Upper), British Columbia: Allan, 13.
Channahon limestone, Silurian, Illinois: Savage, 1007, 1008.
Chase quartzite member, pre-Cambrian, British Columbia: Daly, 279.
Chattahoochee formation, Oligocene, Florida: Matson and Sanford, 768; Sellards and Gunter, 1038.
Chattanooga shale, Devonian, Tennessee: Burchard, 135.
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Chazy, Ordovician, Quebec, Ontario: Raymond, 952.
Chehalis formation, Eocene, Washington: Arnold and Hannibal, 18.
Chelmsford sandstone, pre-Cambrian, Ontario: Coleman, 231, 237.
Chemung formation, Devonian, New York, Pennsylvania: Barrell, 45.
Chemung sandstone member, Devonian, Maryland: Swartz, 1137.

Chesapeake group, Miocene, Virginia: Sanford, 1004.

Chetang limestones, Cambrian, British Columbia and Alberta: Walcott, 1225.

Chickamauga limestone, Ordovician, Tennessee: Burchard, 135.

Chieftain Hill volcanics, Tertiary (?), British Columbia: Cairnes, 158.

Chilliwack series, Carboniferous, Washington, British Columbia: Daly, 278.

Chilliwack volcanic formation, Carboniferous, Washington, British Columbia: Daly, 278.

Chipola marl member, Oligocene, Florida: Matson and Sanford, 768.

Choctawhatchee marl, Miocene, Florida: Matson and Sanford, 768; Sellards and Gunter, 1038.

Chopaka basic intrusives, Carboniferous?, Washington: Daly, 278.

Choptank formation, Miocene, Virginia: Sanford, 1004.

Chouteau limestone, Carboniferous, Missouri: Keyes, 604.

Chugwater formation, Triassic, Wyoming: Blackwelder, 76.

Cisco formation, Carboniferous, Texas: Gordon, 416.

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Claggett formation, Cretaceous, Alberta: Malcolm, 741.

Claggett shale, Cretaceous, Montana: Stebinger, 1105.

Clarksburg limestone, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.

Clarksburg red shale, Carboniferous, West Virginia: Hennen and Reger, 479.

Clear Fork formation, Permian, Texas: Gordon, 416.

Clearwater shale, Cretaceous, Alberta: Malcolm, 741.

Cleveland shale, Devonian, Ohio; Prosser, 932.

Cleveland shale, Mississippian, Ohio: Burroughs, 140.

Clinch sandstone, Ordovician-Silurian, Virginia, West Virginia, Kentucky: Grabau, 427.

Clinton formation, Silurian, New York: Kindle and Taylor, 619.

Clinton formation, Silurian, Ontario: Parks, 887, 888.

Clinton limestone, Silurian, New York and Ontario: Taylor, 1149.

Clinton lower limestones, Silurian, New York and Ontario: Schuchert, 1023.

Clinton shale, Silurian, New York and Ontario: Schuchert, 1023.

Clinton upper limestone, Silurian, New York and Ontario: Schuchert, 1023.

Coalburg sandstone, Carboniferous, West Virginia: Krebs and Teets, 640.

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Cobalt series, pre-Cambrian, Ontario and Quebec: Wilson, 1303.

Cobleskill dolomite, Silurian, New York: Kindle and Taylor, 619.

Coconino sandstone, Pennsylvanian, Arizona: Robinson, 987.

Coeymans member, Devonian, Maryland: Swartz *et al.*, 1138.

Coldbrookian Cambian, Nova Scotia, New Brunswick: Hyde, 543.

Coldbrookian, pre-Cambrian, New Brunswick: Young, 1347.

Coldwater group, Eocene?, British Columbia: Drysdale, 331.

Coldwater series, Oligocene, British Columbia: Camsell, 170.

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Collingwood formation, Ordovician, Ontario: Foerste, 378; Parks, 890.

Collingwood formation, Ordovician, Quebec, Ontario: Raymond, 952.

Colorado formation, Cretaceous, Montana: Emmons and Calkins, 360.

Colorado shale, Cretaceous, Montana: Stebinger, 1105.

Colquitz gneiss, Mesozoic, British Columbia: Clapp, 199.

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Conemaugh series, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.

Connellsville sandstone, Carboniferous, Ohio: Condit, 251.

Connellsville sandstone, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.

Connellsville (lower) sandstone, Carboniferous, West Virginia: Hennen and Reger, 479.

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Connoquenessing (lower), Carboniferous, West Virginia: Hennen and Reger, 479.

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Cordova sands and gravels, Pleistocene, British Columbia: Clapp, 199.
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Cortlandt series, pre-Cambrian, New York: Kemp, 588.
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Cougar formation, pre-Cambrian, British Columbia: Daly, 279.
Coutchiching, pre-Cambrian, Lake Superior region: Lawson, 665.
Coutchiching, pre-Cambrian, Ontario: Uglow, 1183.
Coutchiching series, pre-Cambrian, Canada: Wilson, 1304.
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Creston formation, pre-Cambrian, British Columbia: Schofield, 1020.
Creston red shale, Carboniferous, West Virginia: Hennen and Reger, 479.
Crill limestone, Cretaceous, Iowa: Keyes, 609.
Croasdale quartzite, Silurian, New Jersey: Grabau, 427.
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Cucuracha formation, Oligocene, Panama Canal Zone: MacDonald, 723, 726.
Culebra formation, Oligocene?, Panama Canal Zone: MacDonald, 723.
Culebra formation, Tertiary (Eocene or Oligocene), Panama Canal Zone: MacDonald, 726.
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Cutler formation, Permian, Colorado: Butters, 153.
Cyrene member, Silurian, Illinois and Missouri: Savage, 1007, 1008.
Dakota, Cretaceous, Manitoba, Saskatchewan: Dowling, 326.
Dakota formation, Cretaceous, Alberta: Leach, 666; Malcolm, 741.
Dakota? formation, Cretaceous, Colorado: Grout *et al.*, 450.
Dakota sandstone, Cretaceous, New Mexico: Lee, 671.
Dakota sandstone, Cretaceous, North Dakota: Leonard, 678.
Dawson arkose, Tertiary (Eocene), Colorado: Lee, 671.
Day Creek dolomite, Permian, Oklahoma: Snider, 1078.
Decewsville formation, Devonian, Ontario: Kindle, 616.
De Courcy formation, Cretaceous (Upper), British Columbia: Clapp, 199.
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Dennys formation, Silurian, Maine: Bastin and Williams, 56; Williams, 1289.
Denver formation, Eocene, Colorado: Knowlton, 632.
Denver formation, Tertiary (Eocene), Colorado: Knowlton, 632.
Departure Bay calcarenites, Cretaceous (Upper), British Columbia: Clapp, 199.
Des Moines formation, Pleistocene, Iowa: Tilton, 1159.
Dewdney formation, Cambrian, Idaho and British Columbia: Daly, 278.
Dog Creek shale member, Permian, Oklahoma: Snider, 1078.
Dolores formation, Triassic, Colorado: Butters, 153.
Don beds, Pleistocene, Ontario: Coleman, 234, 236.
Double Mountain formation, Permian, Texas: Gordon, 416.
Dry Creek shale, Cambrian, Montana: Knopf, 626.
Dunkard series, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.
Dunnellon formation, Pliocene, Florida: Sellards, 1036.
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Eagle formation, Cretaceous, Alberta: Malcolm, 741.
Eagle granodiorite, Jurassic, British Columbia: Camsell, 170.
Eagle sandstone, Cretaceous, Montana: Stebinger, 1105.
East Lynn sandstone, Carboniferous, West Virginia: Krebs and Teets, 640.
Eastport formation, Silurian, Maine: Bastin and Williams, 56; Williams, 1289.
Eastwellington formation, Cretaceous (Upper), British Columbia: Clapp, 199.
Eden clays, Ordovician, Ontario: Foerste, 378.
Eden formation, Ordovician, Ontario: Parks, 890.
Eden limestone, Ordovician, Ontario: Foerste, 378.
Edgewood limestone, Silurian, Illinois and Missouri: Savage, 1007, 1008.
Edmonton, Cretaceous, Saskatchewan, Alberta: Dowling, 326.
Edmonton formation, Cretaceous, Alberta: Dowling, 327; MacLean, 736; Malcolm, 741.

Edmunds formation, Silurian, Maine: Bastin and Williams, 56; Williams, 1289.

Eldon formation, Cambrian (Middle), Alberta, British Columbia: Allan, 13.

Elephant limestone, Carboniferous (Pennsylvanian?), Utah: Butler, 147.

Elk conglomerates, Cretaceous, Alberta: Leach, 666.

Elk Lick limestone, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.

Elk River formation, Pliocene, Oregon: Arnold and Hannibal, 18.

Ellensburg formation, Miocene, Washington: Waring, 1232.

Ellis formation, Jurassic, Montana: Emmons and Calkins, 360; Pardee, 880.

Elm Grove limestone, Carboniferous, West Virginia: Hennen and Reger, 479.

Embar formation, Permian?, Wyoming: Blackwelder, 76.

Emperador limestone, Oligocene, Panama Canal Zone: MacDonald, 723, 726.

Empire formation, Miocene, Oregon: Arnold and Hannibal, 18.

Empire shale, Algonkian, Montana: Knopf, 626.

Enid formation, Permian, Oklahoma: Snider, 1078.

Eparchean interval, pre-Cambrian, Lake Superior region: Lawson, 665.

Essex limestone, Silurian, Illinois and Missouri: Savage, 1007, 1008.

Etcheminian, Cambrian, New Brunswick: Young, 1347.

Etcheminian, Cambrian, Nova Scotia: Hyde, 543.

Etna quartz monzonite porphyry: Crawford, 266.

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Ewing limestone, Carboniferous, West Virginia: Hennen and Reger, 479.

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Fabre series, pre-Cambrian, Ontario: Collins, 247.

Fairview formation, Cambrian (Lower), Alberta, British Columbia: Allan, 13.

Fayette formation, Devonian, Iowa: Keyes, 610.

Fernando formation, Tertiary, California: Louderback, 703.

Fernie formation, Jurassic, Alberta: Leach, 666.

Fernie shale, Jurassic, Alberta: Allan, 13; Malcolm, 741.

Fernie shale, Jurassic, British Columbia, Alberta, Saskatchewan: Dowling, 326.

Fish Creek sandstone, Carboniferous, West Virginia: Hennen and Reger, 479.

Fish Haven dolomite, Ordovician, Utah: Richardson, 975.

Fitch Hill arkose, New Hampshire: Lahee, 644.

Fitch Hill granite gneiss, New Hampshire: Lahee, 644.

Flathead beds, Cretaceous, Alberta: Leach, 666.

Flathead quartzite, Cambrian, Montana: Billingsley, 75; Emmons and Calkins, 360; Knopf, 626.

Fordham gneiss, pre-Cambrian, New York: Kemp, 588.

Fort Payne formation, Carboniferous, Tennessee: Burchard, 135.

Fort St. John shales, Cretaceous, Alberta: Malcolm, 741.

Fort St. John shales, Cretaceous, British Columbia: Galloway, 394.

Fort Union formation, Tertiary, Montana: Rogers, 995; Stebinger, 1105.

Fort Union formation, Tertiary (Eocene), North Dakota: Herald, 481.

Fort Union formation, Tertiary, North Dakota: Leonard, 678.

Fort Union formation, Tertiary, Wyoming: Wegemann, 1259.

Fountain formation, Pennsylvanian, Colorado: Butters, 153.

Fox Hills sandstone, Cretaceous, North Dakota: Leonard, 678.

Freeport (lower) limestone, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.

Freeport (lower) sandstone, Carboniferous, West Virginia: Hennen and Reger, 479.

Freeport (upper) limestone, Carboniferous, West Virginia: Hennen and Reger, 479.

Freeport (upper) sandstone, Carboniferous, West Virginia; Hennen and Reger, 479. Krebs and Teets, 640.

Fulton green shale, Carboniferous, West Virginia: Hennen and Reger, 479.

Fulton shale, Ordovician, Cincinnati region: Grabau, 427.

Gabriola formation, Cretaceous (Upper), British Columbia: Clapp, 199.

Galisteo sandstone, Tertiary?, New Mexico: Lee, 671.

Galton series, Montana and British Columbia: Daly, 278.

Garden City limestone, Ordovician, Utah: Richardson, 975.

Garfield formation, Pennsylvanian, Colorado: Crawford, 266.

Gaspe sandstone, Devonian, Quebec: Clarke, 213.

Gasport limestone member, Silurian, New York: Kindle and Taylor, 619.

Gateway formation, Cambrian?, British Columbia: Schofield, 1020.

Gateway formation, Montana and British Columbia: Daly, 278.

Gatun formation, Oligocene, Panama Canal Zone: MacDonald, 723, 726.

Genesee black shale, Devonian, Maryland: Swartz, 1137.

Geneva limestone, Devonian, Indiana: Kindle, 616.

George River series, pre-Cambrian, Nova Scotia: Young, 1347.
Gila conglomerate, Quaternary, Arizona: Meinzer, 785.
Gilboy sandstone, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.
Gilmore limestone, Carboniferous, West Virginia: Hennen and Reger, 479.
Gilmore sandstone, Carboniferous, West Virginia: Hennen and Reger, 479.
Girardeau limestone, Silurian, Illinois and Missouri: Savage, 1007, 1008.
Glacier division, pre-Cambrian, British Columbia: Daly, 279.
Gold-bearing series, pre-Cambrian, Nova Scotia: Faribault, 367.
Goldenville formation, Cambrian, or pre-Cambrian, Nova Scotia: Malcolm, 740.
Goldenville formation, pre-Cambrian, Nova Scotia: Faribault, 367.
Goodsir shales, Ordovician, British Columbia: Allan, 13.
Grafton sandstone, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.
Grainger shale, Devonian and Carboniferous, Tennessee: Burchard, 135.
Grampian limestone, Cambrian? and Ordovician, Utah: Butler, 147.
Grand Forks schist, Washington, British Columbia: Daly, 278.
Grand Grève beds, Devonian, Quebec: Clarke, 213.
Grand Rapids sandstone, Cretaceous, Alberta: Malcolm, 741.
Grand Rapids (lower) formation, Carboniferous, Michigan: Gregory, 442.
Grand Rapids (upper) formation, Carboniferous, Michigan: Gregory, 442.
Grassy black shales, Carboniferous, Missouri, Iowa: Keyes, 604.
Great Smoky formation, Cambrian, North Carolina, Georgia: La Forge and Phalen, 643.
Greenbrier limestone, Mississippian, West Virginia: Hennen and Reger, 479.
Green Pond conglomerate, Silurian, New York, New Jersey: Grabau, 427.
Green River formation, Tertiary, Colorado: Woodruff, 1325.
Greer formation, Permian, Oklahoma: Snider, 1078.
Grenville series, pre-Cambrian, Canada: Wilson, 1305.
Grenville series, pre-Cambrian, New York: Kemp, 588; Miller 822.
Grenville series, pre-Cambrian, Ontario: Adams and Barlow, 8; Coleman, 231, 237.
Grenville series, pre-Cambrian, Quebec: Stansfield, 1101.
Greyson(?) shale, Algonkian, Montana: Emmons and Calkins, 360.
Grinnell formation, Cambrian, pre-Devonian, Montana and British Columbia: Daly, 278.
Guelph formation, Silurian, Ontario: Parks, 887.
Halifax formation, Cambrian, Nova Scotia: Malcolm, 740.
Halifax formation, pre-Cambrian, Nova Scotia: Faribault, 367.
Hamilton member, Devonian, Maryland: Prosser *et al.*, 937.
Hamilton shales, Devonian, Ontario: Parks, 886, 887, 890.
Hammond fire clay, Carboniferous, West Virginia: Hennen and Reger, 479.
Hannibal shales, Carboniferous, Missouri, Iowa: Keyes, 604.
Hardman fire clay, Carboniferous, West Virginia: Hennen and Reger, 479.
Harrington formation, Triassic, Utah: Butler, 147.
Haslam formation, Cretaceous (Upper), British Columbia: Clapp, 199.
Hasmark formation, Cambrian, Montana: Billingsley, 75; Emmons and Calkins, 360.
Hastings series, pre-Cambrian, Ontario: Adams and Barlow, 8.
Hawarden shales, Cretaceous, Iowa: Keyes, 609.
Hawthorne formation, Oligocene, Florida: Matson and Sanford, 768.
Hawthorne formation, Oligocene, Florida: Sellards and Gunter, 1038.
Hazleton group, Cretaceous, British Columbia: McConnell, 719.
Hector formation, pre-Cambrian, Alberta: Allan, 13.
Hefty formation, Montana and British Columbia: Daly, 278.
Helderberg formation, Devonian, Maryland: Swartz *et al.*, 1138.
Helena limestone, Algonkian, Montana: Knopf, 626.
High Falls shale, Silurian, New York: Grabau, 427.
Hitka formation, Cambrian, British Columbia and Alberta: Walcott, 1225.
Hodges shale member, Cambrian, Utah: Richardson, 975.
Homewood sandstone, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.
Homewood sandstone, Pennsylvanian, Pennsylvania: Campbell *et al.*, 169.
Horsethief sandstone, Cretaceous, Montana: Stebinger, 1105.
Horton series, Carboniferous, Nova Scotia: Bell, 64.
Hota formation, Cambrian, British Columbia and Alberta: Walcott, 1225.
Hozomeen series, Carboniferous, Washington, British Columbia: Daly, 278.
Hudson series, Ordovician, New York, Pennsylvania: Grabau, 427.

Hundred sandstone, Carboniferous, West Virginia: Hennen and Reger, 479.
Huntingdon formation, Eocene, Washington, British Columbia: Daly, 278.
Huron shale, Devonian, Ohio: Prosser, 932.
Huronian, pre-Cambrian, Canada: Wilson, 1305.
Huronian, pre-Cambrian, Ontario: Collins, 244, 247.
Huronian system, pre-Cambrian, Canada: Wilson, 1304.
Huronian (lower), pre-Cambrian, Lake Superior region: Lawson, 665.
Huronian (lower), pre-Cambrian, Ontario: Coleman, 231, 237; Parsons, 892.
Huronian (upper), pre-Cambrian, Lake Superior region: Lawson, 665.
Huronian (upper) (Animikie), pre-Cambrian, Ontario: Parsons, 892.
Huronian (upper) or Animikie, pre-Cambrian, Ontario: Coleman, 231, 237.
Ice River intrusive complex, post-Cretaceous, Alberta: Allan, 13.
Illecillewaet quartzite, pre-Cambrian, British Columbia: Daly, 279.
Illinoian drift, Quaternary: Deeley, 304.
Illinoian drift, Quaternary, Illinois: Shaw and Savage, 1041.
Ingleside formation, Pennsylvanian, Colorado: Butters, 153.
Intermediate limestone, Devonian, Alberta: Allan, 13.
Intermediate series, Devonian, Alberta: Malcolm, 741.
Inwood marble, pre-Cambrian, New York: Kemp, 588.
Ione formation, Miocene, California: Dickerson, 314.
Irene conglomerate formation, pre-Cambrian, Idaho and British Columbia: Daly, 278.
Irene volcanic formation, pre-Cambrian, Idaho and British Columbia: Daly, 278.
Irondequoit limestone member, Silurian, New York: Kindle and Taylor, 619.
Jackass Mountain series, Cretaceous, British Columbia: Bowen, 93.
Jacksonville formation, Miocene, Florida: Matson and Sanford, 768; Sellards and Gunter, 1038.
James River formation, Ordovician, Nova Scotia: Twenhofel, 1172.
Jefferson dolomite, Devonian, Utah: Richardson, 975.
Jefferson limestone, Devonian, Montana: Emmons and Calkins, 360; Knopf, 626.
Jefferson limestone, Devonian, Montana and British Columbia: Daly, 278.
Jefferson limestone, Devonian, Utah: Hintze, 507.
Jeffersonville limestone, Devonian, Kentucky: Kindle, 616.
Jennings formation, Devonian, Maryland: Barrell, 45; Prosser and Swartz, 930; Swartz, 1137.
Jerseyean drift, Quaternary: Deeley, 304.
Joggins formation, Carboniferous, Nova Scotia: Bell, 64.
Johannian, Cambrian, New Brunswick: Young, 1347.
Johannian, Cambrian, Nova Scotia: Hyde, 543.
Johnstown cement limestone, Carboniferous, West Virginia: Hennen and Reger, 479.
Jollytown limestone, Carboniferous, West Virginia: Hennen and Reger, 479.
Jollytown sandstone, Carboniferous, West Virginia: Hennen and Reger, 479.
Judith River formation, Cretaceous, Montana: Stebinger, 1105.
Juniata formation, Pennsylvania: Grabau, 427.
Kagawong member, Silurian, Ontario: Williams, 1291.
Kaibab limestone, Pennsylvanian, Arizona: Robinson, 987.
Kamloops volcanic group, Miocene?, British Columbia: Drysdale, 331.
Kamouraska formation, Cambrian?, Quebec: Young, 1347.
Kanawha series, Carboniferous, West Virginia: Krebs and Teets, 640.
Kangaroo formation, Permo-Pennsylvanian (?), Colorado: Crawford, 266.
Kansan drift, Quaternary: Deeley, 304.
Kansan (?) drift, Quaternary, Illinois: Shaw and Savage, 1042.
Kansan series, Pleistocene: Alden and Stebinger, 11.
Keefer sandstone, Silurian, Maryland, West Virginia: Grabau, 427.
Keewatin, pre-Cambrian, Canada: Wilson, 1304.
Keewatin, pre-Cambrian, Ontario: Burrows, 144; Coleman, 231, 237; Collins, 244; Miller, 815; Parsons, 892; Uglow, 1183.
Keewatin, pre-Cambrian, Quebec: Bancroft, 36.
Keewatin complex, pre-Cambrian, Ontario: Miller, 817.
Keewatin group, pre-Cambrian, Ontario: Collins, 247.
Keewatin series, pre-Cambrian, Lake Superior region: Lawson, 665.
Keewatin series, pre-Cambrian, Ontario: Miller, 787.
Keppel dolomites, Silurian, Ontario: Grabau, 427.
Kettle River formation, Oligocene, Washington, British Columbia: Daly, 278.
Kettle River formation, Tertiary (Oligocene), British Columbia: LeRoy, 680.
Keweenawan, pre-Cambrian, Canada: Wilson, 1304.
Keweenawan (?), pre-Cambrian, Ontario: Coleman, 237.
Keweenawan, pre-Cambrian, Ontario: Collins, 247; Parsons, 892.
Keweenawan, pre-Cambrian, Quebec: Bancroft, 36.
Keweenawan series, Cambrian or pre-Cambrian, Michigan: Lane, 655.

Keweenawan (Nipigon), pre-Cambrian, Lake Superior region: Lawson, 665.
Key Largo limestone, Pleistocene, Florida: Matson and Sanford, 768.
Keyser member, Devonian, Maryland: Swartz *et al.*, 1138.
Key West oolite, Pleistocene, Florida: Matson and Sanford, 768.
Kigluaik group, pre-Ordovician, Alaska: Moffit, 827; Smith, 1070.
Kintla formation, pre-Devonian, Montana and British Columbia: Daly, 278.
Kishenehn formation, Tertiary, Montana and British Columbia: Daly, 278.
Kitanning (lower) fire clay, Carboniferous, West Virginia: Hennen and Reger, 479.
Kitchener formation, Cambrian, Idaho, Montana, and British Columbia: Daly, 278.
Kitchener formation, pre-Cambrian, British Columbia: Schofield, 1020.
Kitsalas formation, Trias (?), British Columbia: McConnell, 719.
Klusha intrusives, Tertiary (?), British Columbia: Cairnes, 158.
Knob Hill group, Carboniferous and post-Carboniferous, British Columbia: LeRoy, 680.
Knox dolomite, Cambrian and Ordovician, Tennessee: Burchard, 135.
Knoydart formation, Devonian, Nova Scotia: Twenhofel, 1172.
Kokomo limestone, Silurian, Indiana: Kindle, 618.
Kootenai formation, Cretaceous, Alberta: Malcolm, 741.
Kootenai formation, Cretaceous, Montana: Emmons and Calkins, 360; Pardee, 880; Stebinger, 1105.
Kootenay, Cretaceous, British Columbia, Alberta: Dowling, 326.
Kootenay coal measures, Cretaceous, Alberta: Allan, 13.
Kootenay formation, Cretaceous, Alberta: Leach, 666.
Kootenay granite, Jurassic (?), British Columbia: Schofield, 1020.
Koyukuk group, Cretaceous or Jurassic, Alaska: Smith, 1068.
Kruger alkaline body, Tertiary?, Washington, British Columbia: Daly, 278.
Laberge series, Jura-Cretaceous, British Columbia: Cairnes, 158.
LaBiche shales, Cretaceous, Alberta: Malcolm, 741.
Lafayette (?) formation, Pliocene?, Florida: Matson and Sanford, 768.
Lafayette formation, Pliocene?, Virginia: Sanford, 1004.
Lafayette formation, Tertiary, Delaware: Matson, 766.
Lake Agassiz silt, Quaternary, North Dakota: Leonard, 678.
Lake Louise formation, Cambrian (Lower), Alberta, Britsh Columbia: Allan, 13.
Laketown dolomite, Silurian, Utah: Richardson, 975.
Lance formation, Cretaceous or Tertiary, Montana: Rogers, 995.
Lance formation, Cretaceous or Tertiary, North Dakota: Leonard, 678.
Lance formation, Tertiary, Montana: Stebinger, 1105.
Langston limestone, Cambrian, Utah: Richardson, 975.
Las Cascadas agglomerate, Panama Canal Zone: MacDonald, 723, 726.
Laurentian, pre-Cambrian, Canada: Wilson, 1304, 1305.
Laurentian, pre-Cambrian, Lake Superior region: Lawson, 665.
Laurentian, pre-Cambrian, Ontario: Burrows, 144; Coleman, 231, 237; Collins, 244, 247; Miller, 815, 817, 820; Uglow, 1183.
Laurentian, pre-Cambrian, Quebec: Bancroft, 36.
Laurentian system, pre-Cambrian, Ontario: Adams and Barlow, 8.
Laurie formation, pre-Cambrian, British Columbia: Daly, 279.
Lebo shale member, Tertiary, Montana: Rogers, 995, 996.
Leda clay, Pleistocene, Quebec: Stansfield, 1101.
Lennep sandstone, Cretaceous, Montana: Stebinger, 1105.
Leray member of Lowville formation, Ordovician, Ontario: Foerste, 378.
"Leroux formation," Triassic, Arizona: Robinson, 987.
Lévis formation, Ordovician, Quebec: Raymond, 951.
Lewis series, pre-Devonian, Montana and British Columbia: Daly, 278.
Lewistown limestone, Silurian, Pennsylvania: Grabau, 427.
Lightning Creek diorite, Miocene?, Washington, British Columbia: Daly, 278.
Lime Creek shales, Devonian, Missouri, Iowa: Keyes, 604.
Lisburne limestone, Carboniferous, Alaska: Smith, 1068.
Listmore formation, Pennsylvanian, Nova Scotia: Twenhofel, 1172.
"Lithodendron formation," Triassic, Arizona: Robinson, 987.
Little River group, Carboniferous, New Brunswick: Young, 1347.
Lockatong (Gwynedd) shale, Trias, Pennsylvania: Wherry, 1266.
Lockport dolomite, Silurian, New York: Kindle and Taylor, 619.
Lockport dolomite, Silurian, New York and Ontario: Schuchert, 1023.
Lockport dolomite, Silurian, Ontario: Parks, 887, 888.
Lockport formation, Silurian, Ontario: Parks, 890; Williams, 1293.
Lockport (Niagara) limestone, Silurian, New York and Ontario: Taylor, 1149.

Logan sills, pre-Cambrian, Ontario: Parsons, 892.
Lone Star formation, Cambrian, Idaho and British Columbia: Daly, 278.
Longwood shale, Silurian, New Jersey: Grabau, 427.
Loon River shales, Cretaceous, Alberta: Malcolm, 741.
Lorrain granite, pre-Cambrian, Ontario: Miller, 815, 817, 820.
Lorrain series, pre-Cambrian, Ontario: Collins, 244, 247.
Lorrain shale, Ordovician, Ontario: Coleman, 234, 236.
Lorraine, Ordovician, Ontario: Foerste, 378.
Lorraine formation, Ordovician, Ontario: Parks, 889, 890.
Lorraine group, Ordovician, Quebec, Ontario: Raymond, 952.
Lorraine (Frankfort) formation, Ordovician, Quebec: Raymond, 951.
Lostmans River limestone, Pleistocene, Florida: Matson and Sanford, 768.
Loudoun formation, Cambrian, Virginia: Watson and Cline, 1244.
Louisiana limestone, Carboniferous, Missouri, Iowa: Keyes, 604.
Lowerre quartzite, pre-Cambrian, New York: Kemp, 588.
Lowville formation, Ordovician, Ontario: Johnston, 568.
Lowville formation, Ordovician, Quebec, Ontario: Raymond, 952.
Lowville shales, Ordovician, Ontario: Foerste, 378.
Loyalhanna limestone member, Mississippian, Pennsylvania: Campbell *et al.*, 169.
Lucas formation, Devonian, Iowa: Keyes, 610.
Lykins formation, Pennsylvanian and Permian, Colorado: Butters, 153.
Lyman schists, New Hampshire: Lahee, 644.
Lynx limestones, Cambrian, British Columbia and Alberta: Walcott, 1225.
Lyons formation, Pennsylvanian, Colorado: Butters, 153.
McAdam formation, Silurian, Nova Scotia: Twenhofel, 1172.
McAra's Brook formation, Mississippian, Nova Scotia: Twenhofel, 1172.
Maccrady formation, Carboniferous (Mississippian), Virginia: Stose, 1127.
MacDonald formation, Montana and British Columbia: Daly, 278.
McKenzie formation, Silurian, Maryland, West Virginia: Grabau, 427.
McKim graywacke, pre-Cambrian, Ontario: Coleman, 237.
McLeansboro formation, Pennsylvanian, Illinois: Shaw and Savage, 1042.
McNaughton sandstones, Cambrian, British Columbia and Alberta: Walcott, 1225.
Madison limestone, Carboniferous, Montana: Knopf, 626.
Madison limestone, Carboniferous (Mississippian), Montana: Pardee, 880.
Madison limestone, Mississippian, Idaho: Schultz and Richards, 1030.
Madison limestone, Mississippian, Montana: Emmons and Calkins, 360.
Madison limestone, Mississippian, Utah: Richardson, 975.
Mahoning horizon, Carboniferous, Ohio: Condit, 251.
Mahoning sandstone, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.
Mahoning sandstone member, Pennsylvanian, Pennsylvania: Campbell *et al.*, 169.
Mahto sandstones, Cambrian, British Columbia and Alberta: Walcott, 1225.
Malden sandstone, Carboniferous, West Virginia: Krebs and Teets, 640.
Malignant Cove formation, Ordovician?, Nova Scotia: Twenhofel, 1172.
Mancos shale, Cretaceous, New Mexico: Lee, 671.
Manhattan schist, pre-Cambrian, New York: Kemp, 588.
Manitoba, Devonian, Manitoba: McLean, 736.
Manitoban, Devonian, Manitoba: Dowling, 326.
Manitoulin member, Silurian, Ontario: Williams, 1291.
Mannington sandstone, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.
Maquoketa beds, Ordovician, Iowa: Slocum, 1057.
Marble Bay formation, upper Paleozoic, British Columbia: Bancroft, 35.
Marble Canyon limestone, Carboniferous, British Columbia: Drysdale, 331.
Marcellus black shale member, Devonian, Maryland: Prosser *et al.*, 937.
Marianna limestone, Oligocene, Florida, Matson and Sanford, 768.
Marietta (lower) sandstone, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.
Marietta (upper) sandstone, Carboniferous, West Virginia: Hennen and Reger, 479.
Marsh shale, Algonkian, Montana: Knopf, 626.
Martinsburg shale, Ordovician, Pennsylvania: Grabau, 427.
Matagami series, pre-Cambrian, Quebec: Bancroft, 36.
Mauch Chunk formation, Mississippian, Pennsylvania: Barrell, 45; Campbell *et al.*, 169.
Mauch Chunk series, Mississippian, West Virginia: Hennen and Reger, 479.
Maxfield formation, Ordovician, Utah: Hintze, 507.
Maxville limestone, Carboniferous, Michigan: Gregory, 442.

Maysville limestone, Wisconsin: Grabau, 427.

Maywood clays, Pleistocene, British Columbia: Clapp, 199.

Maywood formation, Silurian (?), Montana: Emmons and Calkins, 360.

Meagher limestone, Cambrian, Montana: Knopf, 626.

Medina beds, Silurian, Great Lakes region: Grabau, 427.

Medina formation, Ordovician, Ontario: Parks, 887, 888.

Medina formation, Silurian, New York and Ontario: Schuchert, 1023.

Medina group (lower part), Ordovician or Silurian, New York: Kindle and Taylor, 619.

Medina group (upper part), Silurian, New York: Kindle and Taylor, 619.

Medina sandstone, New York and Ontario: Taylor, 1149.

Mendez formation, Cretaceous, Mexico: White, 1275.

Merced formation, Miocene, Pliocene, California, Oregon, Washington: Arnold and Hannibal, 18.

Mercer (lower) limestone, Carboniferous, West Virginia: Hennen and Reger, 479.

Mesaverde formation, Cretaceous, Colorado: Woodruff, 1325.

Mesaverde formation, Cretaceous, New Mexico: Lee, 671.

Metchosin volcanics, Eocene, British Columbia: Clapp, 199.

Meteor granodiorite, Washington: Weaver, 1251.

Miami oolite, Pleistocene, Florida: Matson and Sanford, 768.

Midway volcanic group, Miocene, Washington, British Columbia: Daly, 278.

Midway volcanic group, Tertiary (Miocene), British Columbia: LeRoy, 680.

Miette sandstones, pre-Cambrian, British Columbia and Alberta: Walcott, 1225.

Millwood, Cretaceous, Manitoba: Dowling, 326.

Millwood shales, Cretaceous, Manitoba: Malcolm, 741.

Mispeck formation, Carboniferous, New Brunswick: Young, 1347.

Modelo formation, Tertiary, California: Louderback, 703.

Moencopie formation, Permian?, Arizona: Robinson, 987.

Monk formation, pre-Cambrian, Idaho and British Columbia: Daly, 278.

Monongahela series, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.

Monroe beds, Silurian, Michigan: Grabau, 427.

Monroe formation, Silurian, Ontario: Parks, 886, 887, 890.

Moose metargillite, pre-Cambrian, British Columbia: Daly, 279.

Monterey formation, Oligocene-Miocene, California, Oregon, Washington: Arnold and Hannibal, 18.

Monterey series, California: Kew and Stoner, 597.

Monterey series, Tertiary, California: Louderback, 703.

Morehouse quartzite, Ordovician and Silurian?, Utah: Butler, 147.

Morgan formation, Utah: Hintze, 507.

Morgantown sandstone, Carboniferous, Ohio: Condit, 251.

Morgantown sandstone, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.

Morgantown sandstone member, Pennsylvanian, Pennsylvania: Campbell *et al.*, 169.

Morrison formation, Jurassic, Colorado: Butters, 153; Grout *et al.*, 450.

Mount Hope formation, Pleistocene, Panama: Brown and Pilsbry, 115.

Mount Morris limestone, Carboniferous, West Virginia: Hennen and Reger, 479.

Mount Roberts formation, Carboniferous?, British Columbia: LeRoy, 680.

Mount Roberts formation, Carboniferous and post-Carboniferous, British Columbia: LeRoy, 680.

Mt. Savage fire clay, Carboniferous, West Virginia: Hennen and Reger, 479.

Mount Stevens group, pre-Devonian, British Columbia: Cairnes, 158.

Mt. Whyte formation, Cambrian (Lower), Alberta, British Columbia: Allan, 13.

Mowitza shale, Devonian, Utah: Butler, 147.

Moydart formation, Silurian, Nova Scotia: Twenhofel, 1172.

Moyie formation, Cambrian, Idaho, Montana, and British Columbia: Daly, 278.

Moyie sills, Idaho, British Columbia: Daly, 278.

Mumm limestones, Cambrian, British Columbia and Alberta: Walcott, 1225.

Murphy marble, Cambrian, Georgia: La Forge and Phalen, 643.

Nakimu limestone, pre-Cambrian, British Columbia: Daly, 279.

Nanaimo series, Cretaceous, British Columbia: Clapp, 199.

Nanjemoy formation, Eocene, Virginia: Sanford, 1004.

Nantahela slate, Cambrian, North Carolina, Georgia: La Forge and Phalen, 643.

Napoleon sandstone, Carboniferous, Michigan: Gregory, 442.

Nashua marl, Pliocene, Florida: Matson and Sanford, 768.

Nebraskan drift, Quaternary: Deeley, 304.

Neihart quartzite, Algonkian, Montana: Emmons and Calkins, 360.

Nelson batholith, Jurassic?, British Columbia: LeRoy, 680.

Newcastle formation, Cretaceous (Upper), British Columbia: Clapp, 199.

New Glasgow conglomerate, Nova Scotia: Young, 1347.
Newland formation, Algonkian, Montana: Emmons and Calkins, 360.
Newman limestone, Carboniferous, Tennessee: Burchard, 135.
Newman limestone, Carboniferous (Mississippian), Virginia: Stose, 1127.
New Scotland member, Devonian, Maryland: Swartz *et al.*, 1138.
Niagara Falls moraine, Quaternary, New York: Kindle and Taylor, 619.
Niagara group, Silurian, New York: Kindle and Taylor, 619.
Nicola formation, Jurassic-Triassic, British Columbia: Drysdale, 331.
Nineveh limestone, Carboniferous, West Virginia: Hennen and Reger, 479.
Nineveh sandstone, Carboniferous, West Virginia: Hennen and Reger, 479.
Niobrara, Cretaceous, Manitoba, Saskatchewan: Dowling, 326.
Niobrara formation, Cretaceous, Alberta, Manitoba, Saskatchewan: Malcolm, 741.
Niobrara formation, Cretaceous, Colorado: Grout *et al.*, 450.
Niobrara formation, Cretaceous, North Dakota: Leonard, 678.
Niobrara limestones, Cretaceous, Iowa: Keyes, 609.
Nipigon, pre-Cambrian, Ontario: Parsons, 892.
Nipissing diabase, pre-Cambrian, Ontario: Collins, 247; Miller, 815, 817, 820.
Nishnabotna sandstones, Cretaceous, Iowa: Keyes, 609.
Noatak sandstone, Carboniferous, Alaska: Smith, 1068.
Noblesville dolomite, Silurian, Indiana: Kindle, 618.
Noix oolite member, Silurian, Illinois and Missouri: Savage, 1007, 1008.
Nome group, Paleozoic, Alaska: Moffit, 827.
Nora limestone, Devonian, Iowa: Thomas, 1155.
Norian series, pre-Cambrian, Canada: Wilson, 1305.
Northumberland formation, Cretaceous (Upper), British Columbia: Clapp, 199.
Nottely quartzite, Cambrian, North Carolina, Georgia: La Forge and Phalen, 643.
Nounan limestone, Cambrian, Utah: Richardson, 975.
Nugget sandstone, Jurassic or Triassic, Idaho: Schultz and Richards, 1030.
Oak Grove sand member, Oligocene, Florida: Matson and Sanford, 768.
Ocala limestone, Oligocene, Florida: Watson and Sanford, 768.
Oceanic beds, Barbados: Cunningham-Craig, 270.
Odanah, Cretaceous, Manitoba: Dowling, 326.
Odanah formation, Cretaceous, Manitoba: Malcolm, 741.
Ogden quartzite, Algonquin and Cambrian, Utah: Hintze, 507.
Ogden quartzite, Cambrian, Utah: Loughlin, 706.
Ohio shale, Devonian, Ohio: Prosser, 932.
Olequa formation, Eocene, Washington: Arnold and Hannibal, 18.
Oljato sandstone member, Triassic, Utah: Gregory, 446.
Onaping tuff, pre-Cambrian, Ontario: Coleman, 231, 237.
Oneida conglomerate, Silurian, New York: Grabau, 427.
Oneonta formation, Devonian, New York: Barrell, 45.
Onondaga formation, Devonian, Ontario: Parks, 886, 887, 890.
Onondaga limestone, Devonian, New York: Kindle, 616; Kindle and Taylor, 619.
Onondaga limestone, Devonian, Ontario: Stauffer, 1102, 1103.
Onondaga shale member, Devonian, Maryland: Prosser *et al.*, 937.
Ontarian, pre-Cambrian, Lake Superior region: Lawson, 665.
Ontarian system, pre-Cambrian, Canada: Wilson, 1304.
Onwatin slate, pre-Cambrian, Ontario: Coleman, 231, 237.
Open Bay group, upper Paleozoic, British Columbia: Bancroft, 35.
Orca group, Paleozoic, Alaska: Capps and Johnson, 178.
Orindan formation, Tertiary, California: Merriam, 792.
Oriskany formation, Devonian, Maryland: Prosser *et al.*, 937; Swartz *et al.*, 1138.
Oriskany sandstone, Devonian, New York: Kindle, 616.
Oriskany sandstone, Devonian, Ontario: Parks, 886, 887, 890; Stauffer, 1102.
Osoyoos batholith, Jurassic, Washington, British Columbia: Daly, 278.
Oswayo formation, Mississippian, New York: Barrell, 45.
Oswego sandstone, Ordovician, New York: Grabau, 427.
Ottawa gneiss, pre-Cambrian, Quebec: Stansfield, 1101.
Ottawa series, pre-Cambrian, Canada: Wilson, 1305.
Otter granite, Tertiary, British Columbia: Camsell, 170.
Ottertail limestone, Cambrian (upper), British Columbia: Allan, 13.
Ouray limestone, Devonian-Mississippian, Colorado: Crawford, 266.
Paget formation, Cambrian (Upper), British Columbia: Allan, 13.
Palm Beach limestone, Pleistocene, Florida: Matson and Sanford, 768.
Pamelia formation, Ordovician, Quebec, Ontario: Raymond, 952.
Pamunkey group, Eocene, Virginia: Sanford, 1004.

Panama formation, Oligocene, Panama Canal Zone: MacDonald, 723, 726.

Paradise limestone, Silurian, Utah: Hintze, 507.

Park granite stock, Tertiary, Washington, British Columbia: Daly, 278.

Park shale, Cambrian, Montana: Knopf, 626.

Park City limestone, Pennsylvanian or Permian, Utah: Hintze, 507.

Parkhead sandstone, Devonian, Maryland: Swartz, 1137.

Parma sandstone, Carboniferous, Michigan: Gregory, 442.

Parson Bay group, Triassic, British Columbia: Bancroft, 35.

Pasayten andesite, Cretaceous, Washington, British Columbia: Daly, 278.

Pasayten series, Cretaceous, Washington, British Columbia: Daly, 278.

Pasayten volcanic formation, Cretaceous, Washington, British Columbia: Daly, 278.

Paskapoo, Tertiary, Saskatchewan, Alberta: Dowling, 326.

Paskapoo series, Cretaceous, Alberta: Malcolm, 741.

Patapsco formation, Cretaceous, Delaware: Matson, 766.

Patapsco formation, Cretaceous, Virginia: Sanford, 1004.

Patton? shale member, Mississippian, Pennsylvania: Campbell *et al.*, 169.

Patuxent formation, Cretaceous, Virginia: Sanford, 1004.

Payette formation, Tertiary, Idaho: Bowen, 91.

Peace River sandstones, Cretaceous, Alberta: Malcolm, 741.

Pelican sandstone, Cretaceous, Alberta: Malcolm, 741.

Pelican shale, Cretaceous, Alberta: Malcolm, 741.

Pembroke formation, Silurian, Maine: Bastin and Williams, 56; Williams, 1289.

Pend d'Oreille group, Carboniferous?, British Columbia: LeRoy, 680.

Pend d'Oreille group, Washington, British Columbia: Daly, 278.

"Peninsular" limestone, Oligocene, Florida: Matson and Sanford, 768.

Perkins group, upper Paleozoic, British Columbia: Cairnes, 158.

Perry formation, Devonian, Maine: Bastin and Williams, 56.

Perry formation, Silurian, Maine: Williams, 1289.

Phillips formation, Cambrian?, British Columbia: Schofield, 1020.

Phillips formation, Montana and British Columbia: Daly, 278.

Phoenix volcanic group, Mesozoic?, Washington, British Columbia: Daly, 278.

Phosphoria formation, Permian?, Idaho: Schultz and Richards, 1030.

Phosphoria formation, Permian?, Utah: Richardson, 975.

Pierre, Cretaceous, Manitoba, Saskatchewan: Dowling, 326.

Pierre formation, Cretaceous, Colorado: Grout *et al.*, 450.

Pierre shale, Cretaceous, North Dakota: Leonard, 678.

Pierre shales, Cretaceous, Alberta: Dowling, 327.

Pilgrim limestone, Cambrian, Montana: Knopf, 626.

Pine Creek limestone, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.

Pittsburg limestone, Carboniferous, Ohio: Condit, 251.

Pittsburgh limestone, Carboniferous, West Virginia: Krebs and Teets, 640.

Pittsburgh red shale, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.

Pittsburgh sandstone, Carboniferous, West Virginia: Hennen and Reger, 479.

Pittsburgh (lower) limestone, Carboniferous, West Virginia: Hennen and Reger, 479.

Pittsburgh (lower) sandstone, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.

Pittsburgh (upper) sandstone, Carboniferous, West Virginia: Krebs and Teets, 640.

Pittsford shale, Silurian, New York: Grabau, 427.

Pocono formation, Mississippian, Pennsylvania: Campbell *et al.*, 169.

Pocono sandstone, Mississippian, Appalachian region: Barrell, 45.

Pocono series, Mississippian, West Virginia: Hennen and Reger, 479.

Point Edward formation, Carboniferous (Pennsylvanian), Nova Scotia: Hyde, 543.

Pomeroy quartz monzonite, Colorado: Crawford, 266.

Pomeroy sandstone, Carboniferous, West Virginia: Krebs and Teets, 640.

Ponca sandstone, Cretaceous, Iowa: Keyes, 609.

Pontiac group, pre-Cambrian, Quebec: Bancroft, 36.

Poquag quartzite, pre-Cambrian, New York: Kemp, 588.

Porcupine Hill beds, Cretaceous, Alberta: Malcolm, 741.

Portage formation, Devonian, New York: Barrell, 45.

Portersville horizon, Carboniferous, Ohio: Condit, 251.

Portersville limestone or shale, Carboniferous, Ohio: Mark, 747.

Potomac group, Cretaceous, Virginia: Sanford, 1004.

Potsdam sandstone, Cambrian, Quebec: Raymond, 952.

Pottsville formation, Pennsylvanian, Illinois: Shaw and Savage, 1042.

Pottsville formation, Pennsylvanian, Pennsylvania: Campbell *et al.*, 169.
Pottsville series, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.
Pottsville (upper), Carboniferous, West Virginia: Krebs and Teets, 640.
Pre-Wisconsin drift, Quaternary, New York: Kindle and Taylor, 619.
Price sandstone, Carboniferous, Mississippian, Virginia: Stose, 1127.
Prichard quartzite, Algonkian, Montana: Emmons and Calkins, 360.
Priest River terrane, Idaho, Washington, British Columbia: Daly, 278.
Prince Rupert formation, upper Paleozoic?, British Columbia: McConnell, 719.
Princeton batholith, Colorado: Crawford, 266.
Princeton quartz monzonite, Colorado: Crawford, 266.
Proctor sandstones, Carboniferous, West Virginia: Hennen and Reger, 479.
Protection formation, Cretaceous (Upper), British Columbia: Clapp, 199.
Prout limestone, Devonian, Ohio: Prosser, 932.
Purcell lava, Cambrian?, British Columbia: Schofield, 1020.
Purcell lava formation, Montana and British Columbia: Daly, 278.
Purcell series, Idaho, Montana, and British Columbia: Daly, 278.
Purcell sills, Cambrian?, British Columbia: Schofield, 1020.
Puyallup epoch (interglacial), Pleistocene, Washington: Bretz, 101.
Puyallup interglacial deposits, Pleistocene, British Columbia: Clapp, 199.
Quadrant formation, Pennsylvanian, Montana: Emmons and Calkins, 360; Pardee, 880.
Quadrant quartzite, Carboniferous, Montana: Knopf, 626.
Quartermaster formation, Permian, Oklahoma: Snider, 1078.
Quebec City formation, Ordovician, Quebec: Raymond, 951.
Queen Charlotte Islands formation, Cretaceous, British Columbia: Drysdale, 331.
Queenston formation, Ordovician, New York and Ontario: Schuchert, 1023.
Queenston member, Ontario: Parks, 888.
Queenston shale, Ordovician or Silurian, New York: Kindle and Taylor, 619.
Queenston shales, New York: Grabau, 427.
Quoddy shale, Silurian, Maine: Bastin and Williams, 56; Williams, 1289.
Rapid formation, Devonian, Iowa: Keyes, 610.
Ramsay Lake quartzite, pre-Cambrian, Ontario: Coleman, 237.
Raritan formation, Cretaceous, Delaware: Matson, 766.
Raton formation, Eocene, Colorado and New Mexico: Knowlton, 632; Lee, 671.
Ravalli formation, Algonkian, Montana: Emmons and Calkins, 360.
Rawhide formation, Carboniferous?, British Columbia: LeRoy, 680.
Rawhide formation, Carboniferous and post-Carboniferous, British Columbia: LeRoy, 680.
Reade formation, Mississippian, Utah: Hintze, 507.
Red Head formation, Carboniferous, New Brunswick: Young, 1347.
Red Lion formation, Cambrian, Montana: Billingsley, 75; Emmons and Calkins, 360.
Redstone limestone, Carboniferous, West Virginia: Hennen and Reger, 479.
Redwall limestone, Mississippian, Arizona: Robinson, 987.
Red Warrior limestone, Silurian? and Devonian?, Utah: Butler, 147.
Remmel batholith, Jurassic, Washington, British Columbia: Daly, 278.
Rensselaer grit, Devonian, New York, Massachusetts: Barrell, 45.
Rex chert member, Permian(?), Idaho: Schultz and Richards, 1030.
Richmond, Ordovician, Ontario: Foerste, 378.
Richmond formation, Ordovician, Ontario: Parks, 889, 890.
Richmond group, Ordovician, Quebec, Ontario: Raymond, 952.
Richter Mountain hornblendite, Carboniferous?, Washington, British Columbia: Daly, 278.
Ridgely sandstone member, Devonian, Maryland: Swartz *et al.*, 1138.
Ripple formation, Cambrian, Idaho and British Columbia: Daly, 278.
Riverdale formation, Nova Scotia: Hyde, 543.
Riverside sands, Tertiary, Iowa: Keyes, 611.
Robson limestones, Ordovician, British Columbia and Alberta: Walcott, 1225.
Rochester shale, Silurian, New York and Ontario: Schuchert, 1023.
Rochester shale, Silurian, Ontario: Parks, 887, 888.
Rochester shale member, Silurian, New York: Kindle and Taylor, 619.
Rock Creek chonolith, Jurassic, Washington, British Columbia: Daly, 278.
"Rockwood" formation, Silurian, Tennessee: Burchard, 135.
Rocky Mountain quartzite, Pennsylvanian, Alberta: Allan, 13; Shimer, 1145.
Romney formation, Devonian, Maryland: Prosser *et al.*, 937.
Roosville formation, Cambrian?, British Columbia: Schofield, 1020.
Roosville formation, Montana and British Columbia: Daly, 278.
Rose quartzite, pre-Cambrian, British Columbia: Daly, 279.

Ross Brook formation, Silurian, Nova Scotia: Twenhofel, 1172.
Rossland alkali granite, Tertiary, British Columbia: LeRoy, 680.
Rossland group, Carboniferous and post-Carboniferous, British Columbia: LeRoy, 680.
Rossland monzonite, Washington, British Columbia: Daly, 278.
Rossland volcanic group, Washington, British Columbia: Daly, 278.
Rossland Mountain group, Washington, British Columbia: Daly, 278.
Round Knob horizon, Carboniferous, Ohio: Condit, 251.
Rush Run sandstone, Carboniferous, West Virginia: Hennen and Reger, 479.
Rykert granite batholith, Jurassic?, Washington, Idaho, British Columbia: Daly, 278.
Saanich formation, Pleistocene, Washington and British Columbia: Arnold and Hannibal, 18.
Saanich granodiorite, Mesozoic, British Columbia: Clapp, 199.
Saginaw coal series, Carboniferous, Michigan: Gregory, 442.
St. Alban beds, Devonian, Quebec: Clarke: 213.
St. Charles limestone, Cambrian, Utah: Richardson, 975.
St. Cloud sandstone, Carboniferous, West Virginia: Hennen and Reger, 479.
St. John group, Cambrian and Ordovician, New Brunswick: Young, 1347.
St. Mary River beds, Cretaceous, Alberta: Malcolm, 741.
St. Mary River series, Cretaceous or Tertiary?, Alberta: Dowling, 327.
St. Mary's formation, Miocene, Virginia: Sanford, 1004.
St. Piran formation, Cambrian (Lower), Alberta, British Columbia: Allan, 13.
Salina beds, Silurian, Ontario: Stauffer, 1102.
Salina deposits, Silurian, New York, Michigan: Grabau, 427.
Salina formation, Silurian, New York: Kindle and Taylor, 619.
Salina formation, Silurian, Ontario: Parks, 887.
Salmon Arm schist member, pre-Cambrian, British Columbia: Daly, 279.
Salmon River sandstone, Ordovician, New York: Grabau, 427.
Saltsburg sandstone, Carboniferous, West Virginia: Hennen and Reger, 479; Krebs and Teets, 640.
Saltsburg sandstone member, Pennsylvanian, Pennsylvania: Campbell *et al.*, 169.
San Felipe series, Cretaceous, Mexico: White, 1275.
Sangamon soil, Quaternary, Illinois: Shaw and Savage, 1042.
Sangamon soil and loess, Quaternary: Deeley, 304.
San Lorenzo formation, Oligocene, Washington: Arnold and Hannibal, 18.
San Pablo formation, California: Clark, 207.
Santa Fe marls, Tertiary, New Mexico: Henderson, 478.
Saverton shales, Carboniferous, Missouri, Iowa: Keyes, 604.
Sawatch quartzite, Cambrian, Colorado: Crawford, 266.
Sawback formation, Devonian, Alberta: Allan, 13.
Scarboro beds, Pleistocene, Ontario: Coleman, 234, 236.
Scotland beds, Tertiary?, Barbados: Cunningham-Craig, 270.
Seattle formation, Oligocene, Washington and Oregon: Arnold and Hannibal, 18.
Seine series, pre-Cambrian, Ontario: Uglow, 1183.
Selkirk series, Cambrian?, British Columbia: LeRoy, 680.
Selkirk series, pre-Cambrian, British Columbia: Daly, 279.
Senecan group, Devonian, New York, Pennsylvania: Barrell, 45.
Sequatchie formation, Silurian, Appalachian Valley: Ulrich, 1187.
Sergeant shales, Cretaceous, Iowa: Keyes, 609.
Sespe formation, Tertiary, California: Louderback, 703.
Sevier shales, Ordovician, Tennessee: Grabau, 427.
Sewickley limestone, Carboniferous, West Virginia: Hennen and Reger, 479.
Sewickley (lower) sandstone, Carboniferous, West Virginia: Hennen and Reger, 479.
Sewickley (upper) sandstone, Carboniferous, West Virginia: Hennen and Reger, 479.
Sexton Creek (Brassfield) limestone, Silurian, Illinois and Missouri: Savage, 1007, 1008.
Seymour formation, Pleistocene, Texas: Gordon, 416.
Sharon conglomerate, Carboniferous, West Virginia: Hennen and Reger, 479.
Shawangunk conglomerate, Silurian, New York, Pennsylvania: Grabau, 427.
Sheppard formation, pre-Devonian, Montana and British Columbia: Daly, 278.
Sheppard granite, Eocene?: Daly, 278.
Sherbrooke formation, Cambrian (Upper), British Columbia: Allan, 13.
Shinarump clay, Triassic, Utah: Lawson, 663.
Shinarump conglomerate, Triassic, Arizona, Utah, Colorado, New Mexico: Gregory, 446.
Shinarump conglomerate, Triassic, Utah: Lawson, 663.
Shinarump group, Triassic, Utah: Lawson, 663.

Shinarump group, Triassic and Permian, Arizona: Robinson, 987.
Shoal River marl member, Oligocene, Florida: Matson and Sanford, 768.
Shriver chert member, Devonian, Maryland: Swartz *et al.*, 1138.
Shulie formation, Carboniferous, Nova Scotia: Bell, 64.
Shuswap series, pre-Cambrian, British Columbia: Daly, 279; LeRoy, 680.
Sicamous limestone, pre-Cambrian, British Columbia: Daly, 279.
Siestan formation, Tertiary, California: Merriam, 792.
Sillery formation, Cambrian or Ordovician, Quebec: Young, 1347.
Sillery formation, Ordovician, Quebec: Raymond, 951.
Silver Hill formation, Cambrian, Montana: Billingsley, 75; Emmons and Calkins, 360.
Similkameen batholith, Tertiary, Washington, British Columbia: Daly, 278.
Sir Donald formation, Cambrian, British Columbia: Daly, 279.
Siyeh formation, Cambrian?, British Columbia: Schofield, 1020.
Siyeh formation, Cambrian, Montana and British Columbia: Daly, 278.
Skagit harzburgite, Oligocene?, Washington, British Columbia: Daly, 278.
Skagit volcanic formation, Oligocene?, Washington, British Columbia: Daly, 278.
Skeena formation, Cretaceous, British Columbia: McConnell, 719.
Skelley limestone, Carboniferous, Ohio: Condit, 251; Mark, 747.
Skunnemunk conglomerate, Devonian, New Jersey, New York: Barrell, 45.
Slesse diorite, Miocene?, Washington, British Columbia: Daly, 278.
Slocan series, Carboniferous?, British Columbia: LeRoy, 680.
Smelter granite stock, Jurassic, Washington, British Columbia: Daly, 278.
Smoky River shales, Cretaceous, Alberta: Malcolm, 741.
Smoky River shales, Cretaceous, British Columbia: Galloway, 394.
Snyder shales, Devonian, Missouri, Iowa: Keyes, 604.
Sodus shale, Silurian, New York: Grabau, 427.
Sodus shale member, Silurian, New York: Kindle and Taylor, 619.
Soledad beds, Cretaceous, Mexico: Haarman, 453.
Solon formation, Devonian, Iowa: Keyes, 610.
Sooke formation, Oliogocene, Washington and British Columbia: Arnold and Hannibal, 18.
Spence shale member, Cambrian, Utah: Richardson, 975.
Spence's Bridge volcanic group, Jurassic-Cretaceous, British Columbia: Drysdale, 331.
Spokane formation, Algonkian, Montana: Emmons and Calkins, 360.
Spokane shale, Algonkian, Montana: Knopf, 626.
Spokane shale, pre-Cambrian, Montana: Billingsley, 75.
Springvale sandstone, Devonian, Ontario: Stauffer, 1102, 1103.
Steeprock series, pre-Cambrian, Ontario: Uglow, 1183.
Stephen formation, Cambrian (Middle), Alberta, British Columbia: Allan, 13.
Stockton (Norristown) sandstone, Trias, Pennsylvania: Wherry, 1266.
Stonehouse formation, Silurian, Nova Scotia: Twenhofel, 1172.
Stony Mountain formation, Ordovician, Manitoba: Dowling, 326; Malcolm, 741; Wallace, 1230.
Strawn formation, Carboniferous, Texas: Gordon, 416.
Sudbury norite, pre-Cambrian, Ontario: Collins, 247; Miller, 820.
Sudbury series, pre-Cambrian, Ontario: Coleman, 231, 237; Collins, 247.
Sumas granite and diorite, Jurassic?, Washington, British Columbia: Daly, 278.
Summerfield limestone, Carboniferous, Ohio: Condit, 251.
Summit series, Cambrian and pre-Cambrian, Idaho and British Columbia: Daly, 278.
Sundance formation, Colorado: Butters, 153.
Sunderland formation, Pleistocene, Virginia: Sanford, 1004.
Supai formation, Pennsylvanian, Arizona: Robinson, 987.
Sutton formation, Jurassic and Triassic?, British Columbia: Clapp, 199.
Swan Peak quartzite, Ordovician, Utah: Richardson, 975.
Swift Water series, New Hampshire: Lahee, 644.
Sylvania sandrock, Silurian, Ontario: Parks, 890.
Sylvania sandstone, Silurian, Ontario: Parks, 886, 887, 890.
Tah formation, Cambrian, British Columbia and Alberta: Walcott, 1225.
Taku group, Devonian (?), British Columbia: Cairnes, 158.
Talbot formation, Pleistocene, Virginia: Sanford, 1004.
Talisman quartzite, Carboniferous (Pennsylvanian?), Utah: Butler, 147.
Tamasopa limestone, Cretaceous, Mexico: White, 1275.
Tamihy series, Cretaceous?, Washington, British Columbia: Daly, 278.
Tampa formation, Oligocene, Florida: Matson and Sanford, 768; Sellards and Gunter, 1038.

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AND

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USEFUL MINERALS OF THE UNITED STATES.

Compiled by SAMUEL SANFORD and RALPH W. STONE.

INTRODUCTION.

By EDWARD W. PARKER.

The final chapters of two of the earlier volumes of the Geological Survey's annual report entitled "Mineral Resources of the United States" (the volumes for 1882 and 1887) consist of lists of the useful minerals in the United States. No similar lists have been published by the Survey in the last quarter of a century. During that period, however, the mineral resources of the United States have been enormously developed, the value of the total production having increased from $500,000,000 to over $2,000,000,000, and the investigations made by the United States Geological Survey and the State geological surveys have added immensely to the knowledge of the natural resources of the country. It is therefore believed that the present publication is timely. It gives concisely the location, by States, of the principal deposits of useful minerals and includes a glossary showing the composition and character of each mineral and the location of its principal deposits.

Many changes other than increase in production have taken place during the last quarter of a century. Aluminum was not made in the United States in 1887, so that the deposits of bauxite, now the source of material that maintains a great industry, were untouched and were not included in the Survey's lists. Twenty-five years ago the imports of Portland cement were four times the domestic production, and the total quantity consumed was about 1,250,000 barrels. The production of natural rock cement was five times the combined production and imports of Portland cement. To-day the Portland cement industry is distributed generally over the United States, and the production amounts to more than 80,000,000 barrels. The production of natural rock cement and the imports of foreign cement are so small as to be negligible. These are only examples of notable changes in the mineral production of the United States and of correlated changes in the appraised value of some of the mineral deposits.

In this list, as in the earlier lists, it has not been deemed necessary to make the references very detailed. A general statement may give a clearer and more comprehensive view of the occurrences than a minute and specific enumeration of the known deposits; indeed, to state all the localities at which some minerals are found would make the lists too bulky for convenient reference, and they would be useful principally to the professional mineralogist rather than to the miner or manufacturer or the student of economic conditions. The principal localities at which most of the minerals are found are clearly indicated, but the more extensive deposits of some others, such as clay, coal, and iron ore, are mentioned only in general terms.

One material difference will be found between this list and the earlier lists. The form of the earlier lists was twofold, a separate group of items showing the substances "mined" and "not mined" in each State, whereas this list only indicates whether the deposits are, have been, or are not mined or worked. The material in this bulletin is in two distinct parts. In the first part, which consists of lists of the occurrence of minerals in each of the States, the State lists begin with Alabama and end with Wyoming. Under each State the minerals found there are given in alphabetic sequence. The second part is a glossary of more than 425 names. Each definition is followed by a list of the States in which the mineral occurs. It is therefore virtually an index to the first part. In connection with the localities given the reader may find it helpful to refer to Survey Bulletin 507, "The mining districts of the western United States," and to the chapter entitled "Mineral products of the United States" in the report Mineral Resources of the United States for 1912 or later years. Details of occurrence, development, utilization, and market conditions are given in the annual volumes of Mineral Resources of the United States and in the bulletins and other publications of the Survey.

The intention has been to present a list of localities at which minerals occur in sufficient quantity to be of present or possible future value, but the existing literature is very defective in statements of the quantities available at many localities. It may be, therefore, that at some of the localities listed the mineral occurs in quantities so small that it is of scientific interest only, or, if it was once abundant, it may have been completely exhausted by mining or quarrying. Deposits of minerals of wide distribution, such as quartz and calcite, have been omitted, except those that by some unusual feature, such as occurrence in fine crystals or in very pure form or in remarkably large quantity, are of especial interest or value. Some minerals, such as the copper ores of Pennsylvania, are included in the list not because they occur in sufficient quantity to warrant mining for their usual products but because they furnish excellent museum specimens. Some mineral aggregates, as clay, granite, limestone, sand, and sandstone, are included, because they constitute a very considerable part of the mineral production of the country.

This list does not contain discoveries or development later than January 1, 1913, excepting uranium ores. Any corrections of errors or any information concerning deposits not listed will be gratefully received by the authors and will be incorporated in a later edition of the list.

The list was first compiled by Samuel Sanford. Upon Mr. Sanford's transfer to the Bureau of Mines the work was put into the hands of Frank L. Hess, under whose supervision the final revision has been made by Ralph W. Stone. Acknowledgments are due to the following State geologists and others who have cooperated in compiling this list by revising the statements regarding their respective States:

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Wisconsin	Prof. W. O. Hotchkiss, Madison.
Wyoming	Mr. C. E. Jamison, Cheyenne.

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ALABAMA.

Aluminum. *See* Bauxite and Halloysite.

Asbestos. Tallapoosa County, with corundum deposits near Dudleyville; not found in commercial quantity or quality.

Asphalt. Colbert County, small quantity has been shipped from near Leighton; has been obtained also from Russellville and Moulton valleys.

Barite (heavy spar). Very pure and white in residual clays at following localities: Bibb County, Pratts Ferry; Calhoun County, near Tampa; Clay County, T. 20, R. 7 E.; Jefferson County, at Elyton; Lee County, at Chewacla lime works; St. Clair County, at Greensport; Shelby County, near Whiting Station and Calera; Talladega County, in several places.

Bauxite. Cherokee County, mined near Rock Run; known also in Dekalb County, and occurring southward along narrow belt from Georgia State line near Rock Run to Jacksonville, Calhoun County.

Beryl. Coosa County, crystals suitable for gems have been found near Rockford.

Brown iron ore. *See* Limonite.

Cement material (Portland). Portland cement manufactured near Demopolis, Leeds, Ragland, and St. Stephens. Mississippian and Pennsylvanian shales and residual clays, Ordovician and Mississippian limestones abundant in northern Alabama; Cretaceous and Tertiary limestones in southern Alabama.

Chalcopyrite (copper pyrites). Clay County, with pyrite in T. 21, R. 6 E., and near Ashland. Cleburne County, with pyrite in mica schist at Wood's mines and Smith's mines. Tallapoosa County, in T. 23, R. 22 E. Occurs at many localities in Clay, Coosa, Randolph, and Talladega counties and has been mined at some places.

Chalk. Soft, argillaceous, quarried in Dallas County, at Selma; Breene County, at Eutaw; Marengo County, at Demopolis; Sumter County, at Epes; and other localities.

Chert. Calhoun County, at Anniston and Jacksonville. Jefferson County, extensive quarries near Birmingham and Bessemer. Talladega County, several quarries.

Clay (brick). Pits at one or more places in 38 counties. Value of product reported in 1911, $708,903.

Clay (china). Cherokee County, suitable material not worked, occurs as soft white clay at Rock Run. Colbert County, good white ware clay at Pegram. Dekalb County, white, fine sandy at Fort Payne; pits working in pure white clay at Eureka mine 4 miles northeast of Valley Head. Etowah County, white, good ball clay at Gadsden. Marion County, white, fine grained at Chalk Bluff; hard, porous, gritty, adapted to highest grade ware at Pearces Mills. Talladega County, hard, white, micaceous clay, suitable for white tile or earthenware at Kymulga.

Clay (fire). Mined at the following places: Bibb County, at Ashby, Bibbville, and Woodstock. Blount County, at Lehigh, burns buff. Calhoun County, coarse, sandy near Anniston and at Oxanna. Colbert County, black, gritty, burning white at Pegram. Dekalb County, coarse, sandy at Kaolin and Valley Head. Jefferson County, at Littleton, Mabel and Hoagland mines. Marion County, white at Pearces Mills. Russell County, at Girard. Tuscaloosa County, at Hulls Station.

Clay (flint). Abundant in many localities in Choctaw, Clarke, Conecuh, Monroe, and Washington counties.

Clay (porcelain). Dekalb County, dug near Valley Head, hard, white, close to halloysite, used for chinaware.

Clay (pottery). Autauga County, at Edgewood, smooth, plastic, and sandy. Barbour County, was formerly mined for red crockery at Mineral Springs. Cherokee County, occurs at Rock Run. Elmore County, at McLean pottery, burns bluish. Marion County, at Chalk Bluff, reddish, fine grained, and burns red. Pickens County, occurs at Roberts Mill.

Coal (bituminous). Three fields: Cahaba, Coosa, and Warrior; coals all of Pottsville age.

Cahaba field.—Bibb, Shelby, St. Clair, and Jefferson counties, about 290 square miles, 40 coal beds, half workable, some only locally; mined at Acton, Aldrich, Blocton, Coalmont, Garnsey, Glen Carbon, Hargrove, Henryellen, Margaret, Marvel, Maylene, Piper, Sanie, and elsewhere; excellent domestic and steam coals.

Warrior field.—Jefferson, Tuscaloosa, and Walker counties, and southern end of Blount County, 7,800 square miles. Four groups of beds—Black Creek, Brookwood, Mary Lee, and Pratt coal groups. Black Creek coal group mined at Bradford, Coaldale, Empire, Indio, Kimberly, Seloca, Warrior, Wigan, and elsewhere. Brookwood coal group mined at Brookwood, Kellerman, and Searles. Mary Lee coal group mined at Abernant, Adger, Bessie, Davis Creek, Johns, Lewisburg, Littleton, Mulga, Newcastle, Sayre, Sayreton, Sumter, and Yolande, extensively throughout Walker County. Pratt coal group mined at Pratt mines west of Birmingham, Blossburg, Brookside, Cardiff, and Mineral Springs.

Coosa field.—Shelby and St. Clair counties, about 300 square miles; 20 beds, mostly of small area; mined at Coal City and Ragland.

Coal (lignite). Brown coal, wood coal. Occurs in Tertiary of southern and southwestern parts of State at Horse Creek, and at many places eastward in Barbour, Choctaw, Clarke, Marengo, Monroe, Pike, Wilcox, and other counties. Also in Cretaceous, mostly as lignitized trunks, in Greene, Pickens, and other counties. Some of the Tertiary lignites have recently been tested, with satisfactory results, in the clarifying of sugar, and also at the University of Alabama, in gas producer and gas engine.

Copper. Along eastern flank of Talladega Mountain from Chilton County to Georgia State line, small production. *See* Chalcopyrite, Covellite, and Melaconite.

Corundum (emery). Found in various places in gold region, including Coosa County, near Mount Olive and Hanover; Tallapoosa County, near Alexander City and Dudleyville. No deposits of commercial value.

Covellite (indigo copper). Clay County, small quantities with pyrite in sec. 24, T. 19, R. 7 E.

Dolomite. *See* Marble.

Feldspar. Coosa County, mined at Hissop.

Flagstone. Yellow sandstones of Red Mountain, Bucksville to Georgia State line; sandstones of Pennsylvanian series ("Coal Measures") at Plank Shoals on North River. Thin bedded limestone in Mississippian and Ordovician rocks. Gneisses and mica schists of metamorphic region. Quarries at Tallassee Falls in Elmore County.

Galena. Calhoun County, occurs 5 miles west of Jacksonville, was worked during Civil War; Madison County, near New Market; Marshall County, near Guntersville.

Gold. In metamorphic rocks, Chilton, Clay, Cleburne, Coosa, Elmore, Randolph, Talladega, and Tallapoosa counties; for most part, free milling and associated with limonite, resulting from oxidation of pyrite; below water level both free and with pyrite. Chilton County, Blue and Rock creeks. Clay County, Idaho district. Cleburne County, Arbacoochee, Chulafinnee, Kemp Mountain. Coosa County, Rockford and Parsons mines. Elmore County, on Peru Branch. Randolph County, Goldberg, Pinetucky district. Talladega County, near Waldo. Tallapoosa County, Goldville, Hog Mountain district, Silver Hill; cyanide plant at Hog Mountain. Placer mining in Clay, Cleburne, Randolph, and Talladega counties.

Granite. Not much quarried, but occurs in great quantities in Chambers, Chilton, Clay, Cleburne, Coosa, Elmore, Lee, Randolph, and Tallapoosa counties. Quarried in Coosa County about Rockford, and in Randolph County at Wedowee. Thick bedded gneisses quarried in Chambers County at Milltown; Coosa County, Bradford, and Rockford; Lee County, Auburn; Macon County, Notasulga; Randolph County, Blakes Ferry; Tallapoosa County, Tallassee.

Graphite (plumbago). Chilton County, flake graphite mined along Mountain Creek. Clay County, at Ashland, Quenelda, and Stockdale. Coosa County, near Rockford and Goodwater. Randolph County, was formerly mined at Christiana. Tallapoosa County, at Blue Hill and Gregory Hill.

Gypsum. Choctaw, Clarke, and Dallas counties, found in small quantities; not of commercial importance.

Halite. *See* Salt.

Halloysite. Dekalb County, mined at Sulphur Springs for pottery. Jackson County, found near Stevenson. Shelby County, near Calera.

Hematite (Clinton, dyestone, fossil, oolitic, red iron ore). Most important iron ore of State; 1 to 5 beds. Greatest mining district, Jefferson County between Bessemer and Birmingham; also mined in Blount County at Village Springs; Cherokee County, Gaylesville and Round Mountain; Dekalb County, Fort Payne and Valley Head; Etowah County, Attalla and Gadsden; St. Clair County, Springville. Has been mined formerly in Shelby County at Columbiana, and in Tuscaloosa County south and east of Dudley; occurs also in Bibb, Clay, Coosa, Jackson, Marshall, Talladega, and Tallapoosa counties, and in other places.

Hematite (gray iron ore). Talladega County, with variable proportions of magnetite in narrow belt; mined at Emauhee and Mesabi, ore of two types, quartzitic and slaty.

Iron. *See* Hematite, Limonite, Magnetite, Pyrite, Pyrrhotite.

Infusorial earth (tripolite). At many localities in recent and Tertiary formations, including swamp deposits near Mobile and at Montgomery.

Kaolin. In weathered portion of coarse-grained granite veins in Piedmont Province from alteration of feldspar. In Calhoun County, near Jacksonville. Coosa County, at Socopatoy. Randolph County, Louisa. Also found in Chilton, Cleburne, Clay, Elmore, Lee, Macon, and Tallapoosa counties.

Lead. *See* Galena.

Limestone (building stone). Quarried in Blount County, near Blount Springs and Bangor; Calhoun County, at Anniston; Franklin County, at Rockwood. Used in construction of locks on Tennessee River, and at Greenport and other sites on Coosa River. Quarried also in Etowah County at Lagarde, and in Bibb, Colbert, Dekalb, Jefferson, Marshall, Shelby, St. Clair, and Talladega counties.

Limestone (crushed stone). Quarried for macadam, riprap, in Blount County at Chepultepec; Clarke County, Coffeeville; Etowah County, Lagarde; Franklin County, Rockwood and Darlington; Jackson County, Bridgeport; Jefferson County, Gate City; Madison County, Huntsville; Morgan County, Guntersville; Tuscaloosa County, Dowdle between Vance and Bibbville; Washington County, St. Stephens.

Limestone (lime). Quarried and burned in Blount County near Chepultepec; Calhoun County, Anniston; Colbert County, Dennis kilns; Dekalb County, Fort Payne; Etowah County, Rock Springs; Jackson County, Bridgeport; Lee County, Chewacla kilns; Morgan County, New Decatur; Shelby County, about Calera, Keystone, Longview, Newala, Saginaw, and elsewhere; Tuscaloosa County, Dowdle between Vance and Bibbville. *See also* Chalk, Flagstone, Flux, and Lithographic stone.

Limonite. Mined in Bibb and Tuscaloosa counties near Woodstock; Blount County, near Champion; Calhoun County, near Anniston, Jacksonville, Piedmont; Cherokee County, Baker Hill, Bluffton, Langdon City; Franklin County, Russellville; Jefferson County, Birmingham district. Principal ore used in Colbert, Lamar, and Marion counties. Occurs also in Clay, Cleburne, Coosa, and other counties, as gossan of pyritiferous ore; also in concretionary masses.

Lithographic stone. Jackson County, quarried on small scale.

Magnetite (gray iron ore). Chambers County, occurs with hematite near Fredonia and Oak Bowery; Clay County, near Kennedys and Millerville; Coosa County, T. 24, R. 20 E.; Randolph County, Wedowee; Talladega County, Ogdens Mill, Pope Mountain, Mesabi, and Emauhee.

Manganese ore. Manganiferous limonite mined in Bibb County at Woodstock; Calhoun County, near Anniston. *See also* Manganite, Psilomelane, and Pyrolusite.

Manganite. Blount and Etowah counties, occurs in Murphrees Valley; Cherokee County, near Piedmont; Cleburne County, in residual clays near Borden Springs.

Marble (crystalline). Crystalline or statuary along west border of metamorphic rocks from northwest part of Coosa County, through Talladega County into Calhoun County, one-fourth mile wide, 60 miles long; Talladega County, best stone; pure white and white clouded marble near Sylacauga and at Carrara near Talladega. Crystalline dolomite found along east foot of Talladega Mountain range in Chilton and Coosa counties; in Clay County, near Elder post office; and in Lee County at Chewacla quarry, near Opelika.

Marble (noncrystalline). Variegated marble has been quarried in Shelby County, southeast of Calera; in Bibb County, near Pratt Ferry. Marble has been taken also in Colbert County at Dickinson, and in Shelby County, south of Shelby Springs. It occurs also in Franklin, Lauderdale, Lawrence, Madison, and other counties in the northern part of the State. Quarried near Birmingham for flux.

Marl (greensand). Occurs in Autauga, Barbour, Bullock, Butler, Choctaw, Clarke, Coffee, Conecuh, Crenshaw, Elmore, Greene, Hale, Macon, Marengo, Monroe, Perry, Pickens, Pike, Russell, and Wilcox counties.

Marl (shell). Occurs in Butler, Clarke, and Monroe counties.

Melaconite (black copper, black oxide of copper). Cleburne County, was mined with other copper ores at Woods' copper mine.

Mica. *See* Muscovite.

Millstone. Madison County, "Millstone grit" of the Pennsylvanian series ("Coal Measures") quarried for millstones at many points on sides of anticlinal valleys, as near Huntsville; Marion County, ferruginous conglomerate (probably from Lafayette formation) quarried and used; Butler, Choctaw, Clarke, Crenshaw, Monroe, Pike, and Wilcox counties, as buhrstone.

Mineral paint. *See* Barite and Ocher.

Muscovite. Chilton County, mined in T. 22, R. 16; Clay County, in T. 20, R. 6, and near Bowden; Cleburne County, prospected near Micaville; Randolph County, mined in Wedowee, and prospected at Pinetucky mine.

Natural gas. Occurs in scattering wells in Franklin County, at Russellville; Madison County, at Huntersville and Hazelgreen; Walker County, Jasper; Winston County, Haleyville. Largest well in State at Fayette, Fayette County; yielded 4,500,000 cubic feet a day. Natural gas also issues in small quantities from many salt wells in Baldwin, Clarke, Mobile, and Washington counties.

Niter. Obtained in limestone caves, principally in Tennessee River valley, during Civil War, for making gunpowder.

Ocher. Red ocher mined in Etowah County, at Attalla, and found at many other places. Yellow ocher, mined in Autauga County, and in Elmore County, at Coosada station; found also in Fayette, Marion, and Tuscaloosa counties.

Petroleum. Show of oil in wells in northwestern part of State, but no producing wells.

Phosphate rock. Dark and light rock phosphate extends several miles into State from Tennessee along Elk River; in Limestone County, small quantity mined 1 mile west of Veto. Phosphatic greensand, with phosphate nodules, at base of Selma chalk, through or near Eutaw, Greensboro, Hamburg, Marion, Montgomery, Prattville, and Selma.

Potash. *See* Marl and Niter.

Psilomelane (black manganese). Found in several localities in Bibb, Blount, Calhoun, Cherokee, Cleburne, and Tuscaloosa counties.

Pyrite. Clay County, formerly mined and shipped from near Pyriton for sulphuric acid. Randolph County, small quantity at Pinetucky mine, carries gold, and at other gold mines. Occurs with copper ores also in Clay County, and in Cleburne County at Smith's and Wood's copper mines; in Limestone County, abundant at Elkmont.

Pyrolusite (manganese dioxide). Occurs in Blount and Etowah counties, in Murphrees Valley; in Bibb and Tuscaloosa counties; in Cherokee County, north and northwest of Piedmont, and in Cleburne County, in residual clays near Borden.

Pyrrhotite. Cleburne County, was mined at Wood's copper mine near Stonehill; Talapoosa County (auriferous), at Hog Mountain.

Quartz. Friable quartz rock in Chambers, Chilton, Lee, Macon, Randolph, Tallapoosa, and other counties. Fine silica from cherty limestone in Tennessee Valley, may be suited for glass sand; not used.

Quartz (sand). Monroe County, near Claiborne.

Road metal. *See* Chert and Limestone.

Salt. Made from waters of salt wells in Clarke and Washington counties during Civil War.

Sand (building). Dug in Calhoun County, at Anniston; Clarke County, Jackson; Dallas County, Plantersville; Elmore County, Coosada, Grandview, and Jones; Escambia County, Pollard; Etowah County, Alabama City and Gadsden; Jefferson County, Irondale and Truesville; Montgomery County, Montgomery.

Sand (glass). Glass sand from crushed sandstone in Jefferson County, at Gate City, carries 99 per cent SiO_2; also in Etowah County, at Gadsden.

Sand (molding). Dug in Clarke County, at Jackson; Elmore County, at Coosada, Grandview, and Jones; Etowah County, at Alabama City and Gadsden; Jefferson County, at Truesville; St. Clair County, at Cooks Springs.

Sandstone. Quarries: Calhoun County, at Anniston; Colbert County, Cherokee; Cullman County, Cullman; Tuscaloosa County, Tuscaloosa; Walker County, Jasper, and elsewhere. Fayette County, rough stone; Jefferson County, flagstone of Clinton formation used at Birmingham.

Shale. For jetties and ballast, quarried 2½ miles east of Berry and at Ledule. Quarried for making brick in Blount County, at Lehigh; Jefferson County, at Alton, Coaldale, Graves, Lovick, and Shale; Marion County, at Bexar, Glen Allen, and Pearces Mills.

Sienna. Cherokee County, found at Oxford.

Silver. Recovered in refining gold in three deep mines and three placers.

Slate. Promising beds of slate occur in Calhoun County, near Anniston; in Clay County, T. 19, R. 7; in Shelby County, at Buxahatchee Creek; in Talladega County, T. 21, R. 3; also in Chilton, Cleburne, and Coosa counties. Not worked anywhere since the Civil War.

Soapstone. Greenish schistose rock mined in Chambers County, at Oak Bowery for lining kilns, near Dudleyville for hearth stones, T. 22, R. 25, for headstones. Old excavations in Coosa, Lee, and Tallapoosa counties.

Sphalerite (zinc blende). Cleburne County, near Wood's copper mine.

Sulphur. *See* Pyrite and Pyrrhotite.

Tripoli (rotten stone). Largest deposits in Calhoun, Lauderdale, and Talladega counties. Shipments have been made from Talladega County.

Tripolite. *See* Infusorial earth.

Wavellite. St. Clair County, important deposits 5 miles northeast of Coal City, on Coosa River, undeveloped.

Zinc. *See* Sphalerite.

ARIZONA.

Alabaster. Occurs in Superstition Mountains; near Pueblo Viego; near Sulphur Springs; in La Gila Range, and elsewhere.

Andradite. *See* Garnet.

Anglesite (sulphate of lead). Gila County, at Lost Gulch mine, near Globe; Mohave County, in Mineral Park; Pima County, in Mammoth mine, Schulz; Yavapai County, in ores of Bradshaw Mountains; common in silver veins.

Antimony ores. *See* Jamesonite and Stibnite.

Argentite (silver glance). Mohave County, in pre-Cambrian granite gneiss in Chloride, Mineral Park, and Stockton Hill districts. Pinal County, at Silver King; Santa Cruz County, at Montezuma and Empress of India mines, Tyndall district; Yavapai County, in ores of Bradshaw Mountains.

Arsenopyrite (mispickel, arsenical pyrite). Mohave County, in pre-Cambrian granite gneiss in Chloride and Mineral Park districts; Minnesota-Connor, Windy Point, and Queen Bee mines; carries gold and silver; not mined for arsenic. Yavapai County, in veins of Bradshaw Mountains; carries gold and some silver at McCabe mine.

Asbestos (chrysotile). Coconino County, associated with serpentine in limestone at Grand View and Bass Camp, Grand Canyon. Gila County, fine specimen found on Ash Creek, 35 miles northeast of Globe.

Azurite. Cochise County, was abundant at Copper Queen mine, Bisbee district. The finest specimens of azurite in many museums have come from this mine. Gila and Pinal counties, rare in Globe district. Greenlee County, large masses in Longfellow, Manganese Blue, and Shannon mines. Yavapai County, in ores of Bradshaw Mountains.

Azurmalachite. Cochise County, blue azurite and green malachite, an ornamental stone in copper mines of Bisbee district. Mohave County, as impregnation of porphyry at John Kay mine, Mineral Park.

Bismuth. *See* Tetradymite.

Bornite (peacock ore). Cochise County, small quantity in quartz veins in Whetstone Mountains. Mohave County, at Altata and Pinkham mines, Chloride district. Pima County, occasional in Mammoth mine. Pinal County, in Silver King mine. Santa Cruz County, small quantity at Line Boy prospect, near Duquesne. Yavapai County, common in copper veins; in ores of Bradshaw Mountains carries free gold.

Brochantite. Cochise County, small quantities often associated with malachite in Bisbee district; also with cuprite in Copper Queen and in Calumet and Arizona mines. Greenlee County, common with malachite in Clifton-Morenci district; mined at Shannon, Metcalf, Copper Mountain, and Montezuma mines. Yavapai County, United Verde mine, Jerome.

Brongniardite. Associated with other argentiferous ores.

Brown iron ore. *See* Limonite.

Carnotite. Navajo Reservation.

Cement material. Occurs in many places, as at Flagstaff, and near Phoenix. Utilized at Roosevelt Dam.

Celestite. Maricopa County, occurs at Gila Bend.

Cerargyrite (horn silver, chloride of silver). Mohave County, in pre-Cambrian granite gneiss in Chloride, Cerbat, and Stockton Hill districts; mined at Distaff mine, Chloride district. Yavapai County, Bradshaw Mountains district; common in silver veins.

Cerusite (lead carbonate). Cochise County, impure sandy form in Hendricks Gulch, Bisbee district. Greenlee County, mined for gold values at Hormeyer mine, Morenci. Mohave County, in Mineral Park district; Tyler mine. Pima County, in Greaterville placer deposits; silver and gold values. Pinal County, Haley claims, 2½ miles east of Ray. Santa Cruz County, Morning and Flux mines.

Chalcanthite (bluestone). Greenlee County, small quantities mined at Copper Mountain, Clifton-Morenci district. Yavapai County, considerable quantity formerly in United Verde mine, Jerome district.

Chalcedony. Greenlee County, in limestone in Clifton-Morenci district; also loose on Shannon Mountain. Mohave County, gray, white, and purplish on western slope of River Range, and other localities. Santa Cruz County, Grosvenor Hills. *See also* Chrysoprase.

Chalcocite (copper glance). Common below oxidized zone in most copper mines of the State. Cochise County, formerly most important sulphide near Bisbee; in Copper Queen, Calumet, Arizona, and other mines, but chalcopyrite has succeeded it at greater depth; abundant in massive form in Shattuck mine, Bisbee. Gila and Pinal counties, the essential constituent of the disseminated ores in schist and porphyry at Ray and Miami; in the Old Dominion mine, near Globe; with bornite forms rich ore of Queen mine at Superior. Greenlee County, principal copper mineral in Clifton district; in Ryerson and other mines. Mohave County, in Chloride district. Pima County, occurs in Cobriza mine, Cababi district. Yavapai County, in copper-silver veins of Bradshaw Mountains. Yuma County, in prospects at Cinnabar, 8 miles southwest of Quartzsite.

Chalcopyrite (copper pyrites). Found in nearly all of the copper mines of the State. Cochise County, in massive form in Bisbee district; mined at Copper Queen, Calumet, Arizona, and other mines. Gila and Pinal counties, abundant with specularite in Gibson mine as vein in schist, Globe district. With pyrite in veinlets and in disseminated form in so-called "primary ore" of mines at Miami and Ray. Greenlee County, small proportion in copper ore bodies in Clifton-Morenci district. Mohave County, primary ore of Chloride district, in Pay Roll and Redemption mines; primary ore, Mineral Park district, in Keystone, Windy Point, and other mines; Cerbat district, in Cerbat and Alpha mines; Stockton Hill district, in Banner Group and Treasure Hill mines; Helvetia and Silver Bell districts. Pima County, important copper ore at Old Boot, Leader, and Ridley mines; occurs also in quartz veins at McCleary prospects, 10 miles south-southwest of Helvetia. Santa Cruz County, in Tyndall district at American Boy mine. Yavapai County, in ores of Bradshaw Mountains and United Verde mine, Jerome district; auriferous and argentiferous.

Chrysocolla (silicate of copper). Cochise County, Bisbee district, Calumet and Arizona mines, 3 miles north of Dragoon; not abundant. Coconino County, in sandstone of White Mesa of Navajo Indian Reservation. Gila and Pinal counties, formerly a more important ore than at present; in Globe district, abundant in Live Oak, Keystone, Black Warrior, Geneva, and Black Copper mines. Graham County, common, but not important, in Clifton-Morenci district. Yavapai County, in Bradshaw Mountains district, common in outcrops of copper veins; not important.

Chrysolite. *See* Olivine.

Chrysoprase (blue-green chalcedony). Gila County, "blue chrysoprase," copper-stained chalcedony at Live Oak and Keystone mines, near Miami. Mohave County, true chrysoprase on west slope of River Range.

Chrysotile. *See* Asbestos.

Cinnabar. Gila County, reported at Rye. Yavapai County, reported at Skull Valley. Yuma County, sparsely distributed in veins at Cinnabar, 14 miles from Ehrenberg; has been mined on small scale.

Clay (brick). Cochise County, clay made into common and front brick at Benson, Douglas, and Naco; Coconino County, at Williams and Flagstaff; Maricopa County, at Alhambra and Tampa. Navajo County, small quantity dug at Snowflake; Pima County, at Tucson; Pinal County, at Florence; Santa Cruz County, at Nogales; Yavapai County, at Mayer and near Prescott.

Clay (china). *See* Kaolin.

Clay (fire, graphitic). Cochise County, mined in Whetstone Mountains, near Benson; burns white; used for lining converters; used also for manufacture of pressed brick.

Coal (bituminous). Pinal County, Deer Creek field, at the eastern end of the county, 35 miles southeast of Globe, and east of Winkelman; area 30 square miles; two workable beds, 24 to 30 inches; block, coking.

Coal (subbituminous). Apache, Coconino, and Navajo counties, Black Mesa field, in Moqui and Navajo Indian reservations; area approximately 5,920 square miles; coal in two main groups of beds, appears to be in thin benches alternating with layers of shale and bone.

Copper (native). Cochise County, Bisbee district, with cuprite in Calumet & Arizona, Copper Queen, and other mines. Gila and Pinal counties, Globe district, in quartzite, Old Dominion mine. Greenlee County, with other copper ores in Metcalf mines, Clifton-Morenci district, not important. Yavapai County, in ores of Bradshaw Mountains district; not important.

Copper minerals. Ores of copper are of chief importance in the following districts: Cochise County, Courtland, Dragoon, Huachuca, Johnson, and Warren (Bisbee); Coconino County, Francis, Grand Canyon, and Jacobs Lake; Gila County, Black Warrior, Christmas, Globe, Lost Gulch, Miami, and Pinto Creek; Graham and Greenlee counties, Bunker Hill, Clark, Greenlee (Metcalf), Morenci, and

Lone Star; Maricopa County, San Domingo; Mohave County, Bentley and Hualpai; Pima County, Ajo, Amole, Helvetia, Old Baldy, Pima, Rincon, Santa Rosa, and Silver Bell; Pinal County, Bunker Hill, Mineral Creek, Mineral Hill, Pioneer, and Vekol; Santa Cruz County, Patagonia and Washington; Yavapai County, Agua Fria, Black Hills, Copper Basin, and White Picacho; Yuma County, Harcuvar, Planet, Plomosa, Swansea, and Vicksburg. *See* Azurite, Azurmalachite, Bornite, Bournonite, Brochantite, Chalcanthite, Chalcocite, Chalcopyrite, Chrysocolla, Covellite, Cuprite, Malachite, Melaconite, Stromeyrite, Tenorite, and Tetrahedrite.

Coronadite (manganite of lead). Greenlee County, Clifton-Morenci district, fairly abundant near Coronada vein, three-quarters of a mile west of Horseshoe; stated to contain some gold; has been mined.

Covellite (indigo copper, blue copper). Greenlee County, rare in Clifton-Morenci district; in Ryerson and Montezuma mines.

Crocoite (chromate of lead, red lead). Maricopa County, in some of the mines of the Vulture district; occasionally met with in other lead ores.

Cuprite (red oxide of copper). Cochise County, abundant and important ore of Bisbee district; in Calumet, Arizona, and Copper Queen mines. Gila and Pinal counties, in Continental and Buffalo mines, Globe district; Greenlee County, in Clifton, Morenci, and Metcalf mines; Yavapai County, Bradshaw Mountains district; not important.

Descloizite (vanadate of lead). Cochise County, Lucky Cuss mine, Tombstone, Castle Dome district; Mammoth mine in Catalina Mountains, and Old Yuma mine in Tucson Mountains. Pinal County, Dripping Spring Range, 4 miles east of Kelvin, with vanadinite and wulfenite.

Dufrenoysite (arsenical lead ore). Mohave County, associated with other ores of lead, zinc, and silver; mined when argentiferous; Mineral Park.

Dyscrasite (antimonide of silver). Associated with other ores of lead and silver.

Embolite (chlorobromide of silver). Cochise County, especially abundant in Pearce district; occasionally found with other silver ores.

Fluorspar (fluorite). Cochise County, small quantity in quartz veins, 4 miles north of Dragoon; has been mined. Mohave County, gangue mineral of Black Mountain. Yavapai County, gangue mineral of Bradshaw Mountains district.

Freieslebenite (antimonial sulphide of silver). Yuma County, mined at Castle Dome; small quantities shipped. With other argentiferous ores.

Gadolinite. Mohave County, in pegmatite 20 miles south of Hackberry.

Galena. Invariably argentiferous and sometimes slightly auriferous. Gila and Pinal counties, sparingly in Globe and Ray districts; Greenlee County, in Metcalf ores of Clifton-Morenci district, gold bearing (?) in Copper King mine, carries considerable silver in Stevens group. Mohave County, Chloride district; mined at Tennessee, Elkhart, Hercules, and other mines; principal ore of Mineral Park district; mined at Tyler, Lady Bug, and Queen Bee mines; Cerbat district, Idaho and Alexander mines; Stockton Hill district. Pima County, Mammoth mine, argentiferous; Ridley mine, near Helvetia. Yavapai County, common silver mineral of Bradshaw Mountains district; also gold values; Senator and other mines; occurs also in Cochise, Santa Cruz, and Yuma counties.

Garnet. Greenlee County, large masses on western slope of Modoc Point at Morenci, and on top of Shannon Mountain at Metcalf; massive garnet occurs in many of the mining districts; as yellowish to dark brown andradite at Clifton. Yavapai County, common in schists of Bradshaw Mountains. Navajo Reservation, gem pyrope ("Arizona ruby") in extreme northern part of the State; and with peridot 10 miles north of Fort Defiance.

Glauberite (sulphate of soda and lime). Yavapai County, associated with thenardite, halite, and mirabilite, Verde Valley.

Gold (lode). Principal producers are Cochise County, Warren and Tombstone districts; Mohave County, San Francisco district; Yavapai County, Big Bug, Martinez, Tiger, and Verde districts; Yuma County, Kofa district.

Gold (placer). Pima, Yavapai, and Yuma counties are the largest producers. Other counties yielding appreciable quantities are Cochise, Coconino, Gila, Greenlee, and Santa Cruz. Dredges have been erected on Lynx Creek, in the Walker district, Yavapai County, and in French Gulch, a small tributary of Hassayampa River. Other important placers are in Pima County at Greaterville; Yavapai County, at Canada del Oro, Catalina Mountains, and Weaver placers.

Granite. Quarried in Cochise County, at Lee Station; Gila County, at Globe; and Maricopa County, at Phoenix; building and monuments.

Granite (quartz diorite). Gila County, Pinal Range, not used. Yavapai County, Bradshaw Mountains; would make handsome building stone; not used.

Graphite. Pure graphite has not been found. *See* Clay, graphitic.

Gypsum. Cochise County, quarried at Douglas. Navajo County, used for manufacture of plaster in Fort Apache Reservation, Woodruff, and Snowflake. Pima County, occurs in Santa Rita Mountains, Sierrita Mountains, and Santa Catalina Mountains; quarried near Tucson. Cochise and Pinal counties, used for manufacture of plaster in San Pedro Valley. *See also* Alabaster and Halite.

Halite (common salt). Gila County, occurs in headwaters of Salt River and in Tonto Basin. Yavapai County, occurs in Verde Valley associated with glauberite, gypsum, mirabilite, and thenardite; used to a small extent for cattle; too impure for table use.

Hematite. Occurs in gossan of copper deposits at many localities; in Santa Cruz County, at Pluto, Isabella, and other claims; in Yuma County, at Palmer & Wharton claim. Occurs as contact mineral in Cochise County in magnetite on croppings of Black Diamond copper mine, Dragoon; Greenlee County, Clifton-Morenci district; and at Manganese Blue mine. Gila County, mined with copper ores in Globe district.

Hematite (micaceous). Yavapai County, reported from Willcox and Briggs.

Hematite (specular). Gila County, with chalcopyrite in Old Dominion, Superior & Boston, Gibson, and other mines of Globe district. Mohave County, common in Black Mountain and Cerbat Range, Chloride district. Pinal County, occurs near Mammoth. Santa Cruz County, at Line Boy, near Duquesne.

Hübnerite. Cochise County, in veins and placer deposits near Dragoon; the placers are mined. Pima County, in quartz veins cutting granite at Arivaca; mined.

Iron minerals. *See* Arsenopyrite, Hematite, Limonite, Magnetite, Pyrite, and Pyrrhotite.

Jamesonite. Yavapai County, in ores of Bradshaw Mountains; carries free gold.

Jasper. Mohave and Yuma counties, brilliant red, orange to yellow, with chalcedony in petrified forests. Mohave County, dark red and brown on west slope of River range 20 miles west of Mineral Park.

Kaolin (china clay). Gila County, occurs at Globe. Greenlee County, not uncommon at Copper Queen, Morenci, and Metcalf, Clifton-Morenci district; as veinlets in quartz in Humboldt, Ryerson, and other mines; mined at Longfellow mine for converter lining. Pinal County, in Vekol mines.

Lead minerals. *See* Anglesite, Cerusite, Coronadite, Crocoite, Dufrenoysite, Galena, Jamesonite, Leadhillite, and Pyromorphite. Ores of lead are of chief importance in the following districts: Cochise County, California (Paradise); Graham County, Aravaipa; Mohave County, Cedar Valley and Stockton Hill; Pima County, Empire; Yuma County, Castle Dome and Silver.

Leadhillite. Pinal County, rare; occurs with other lead ores at Schulz.

Limestone. Cochise County, quarried for building or lime at Lee Station. Coconino County, at Flagstaff. Gila County, quarried during construction of dam at Roosevelt. Greenlee County, gray Modoc limestone quarried at Morenci. Yavapai County, at Wekon.

Limonite (brown hematite, brown iron ore). Cochise County, Copper Queen mine at Bisbee. Gila and Pinal counties, mined for contained copper in Old Dominion mine, Globe district. Greenlee County, abundant in Clifton-Morenci district, valuable as flux. Mohave County, common in Black Mountains and Cerbat Range, Chloride district. Pima County, coating quartz veins at McCleary prospects near Helvetia. Yavapai County, in ores of Bradshaw Mountains.

Magnetite (magnetic iron ore). Cochise County, Black Diamond mine, Dragoon Range. Greenlee County, Clifton-Morenci district; mined for flux in Manganese Blue and Arizona Central mines. Yavapai County, in ores of Bradshaw Mountains; carries free gold.

Malachite (green carbonate of copper). Cochise County, mined at Bisbee, Copper Queen, and other mines; wonderfully beautiful specimens have been obtained from the Copper Queen mine and placed in various museums. Greenlee County, common in irregular deposits in limestone in Clifton-Morenci district; mined at Detroit, Manganese Blue, Longfellow, and Standard mines. Gila and Pinal counties, abundant in Globe district; associated with copper ores but not itself an important ore constituent. Mohave County, in granite-gneiss, Mineral Park district. Yavapai County, in ores of Bradshaw Mountains.

Manganese. Cochise County, manganese oxide abundant in oxidized ores of certain mines of the Tombstone district. Ore mined for silver in these mines is principally pyrolusite and wad, with some psilomelane. *See also* Coronadite, Psilomelane, Pyrolusite, and Wad.

Marble. Cochise County, medium-grained crystalline, pure white with pinkish tones, beautiful color, suitable for decorative purposes near Fort Bowie; white, pinkish or grayish white, also gray, dove-color, or blue, handsome decorative marble near Emigrant Canyon; coarsely crystalline, granular white, excellent building stone near Whitetail Canyon. Pima County, black marble in Tucson Mountains. Pinal County, white statuary marble at northern end of Catalina Mountains, near Condon mine. Yavapai County, light green to white, weathering producing yellow and red banding, near Mayer, Bradshaw Mountains, deposit ¾ mile by ½ mile, maximum thickness 25 feet, decorative stone; has been quarried; little shipped; onyx marble.

Melaconite (black oxide of copper). Of common occurrence in many mines with other ores of copper.

Mica. *See* Muscovite.

Mineral paint. Hematite near Parker on California side of river; also in Yuma County, 30 miles northeast from Quartzsite, and at Bouse's Well.

Mirabilite. Yavapai County, associated with thenardite, glauberite, and halite, Verde Valley.

Molybdenum. *See* Molybdenite and Wulfenite.

Molybdenite. Gila County, in disseminated ores at Miami. Greenlee County, in copper ores of Clifton-Morenci district. Mohave County, primary ore of Chloride district in granite-gneiss; with copper in Hualpai Mountains, Maynard district. Pima County, in Madera Canyon, 10 miles southwest of Helvetia; in limestone and quartz at Leader and Ridley mines, Helvetia; in workable quantities only at Leader mine; with copper ores at Vail. Pinal County, in ores at Ray and Kelvin mines as original mineral. Santa Cruz County, sparingly in granite at Providencia Canyon, 5 miles west of Washington; also at Duquesne and San Antonio Canyon.

Muscovite (mica). Several deposits, none developed, value unknown. Occurs in Coconino County, on north side of Grand Canyon, and in Maricopa County, White Horse Tank Mountains, southwest of Phoenix.

Obsidian. Occurs in regions of Tertiary volcanic rocks; small quantities cut for jewelry.

Olivine (chrysolite, Job's tears). Apache County, beautiful green, yellowish-green, brownish-green, and brown gems are found 10 miles north of Fort Defiance, in the Navajo Indian Reservation; and in Gila County in basaltic rocks near Rice, in the San Carlos Indian Reservation.

Onyx marble. The most important locality in Arizona is in Yavapai County near Mayer, about 26 miles from Prescott. Occurs also in Maricopa County, at Cavecreek, 45 miles north of Phoenix; Pima County, at Greaterville, Kirkland Valley, and Oak Creek; Yavapai County, at Big Bug Creek.

Opal (cacholong, and hyalite). Pinal County, Picket Post; Yavapai County, several localities.

Platinum. Yavapai County, occurs in black sands near Columbia.

Polybasite. Pinal County, fine specimens were found at Silver King mine; occasionally with other argentiferous ores.

Proustite (light ruby silver). Occurs with other argentiferous ores at many places.

Psilomelane (manganese ore). Cochise County, with pyrolusite and wad in Carboniferous limestone at Tombstone; mined for silver contents.

Pyrargyrite (ruby silver). Mohave County, secondary ore of Chloride, Mineral Park and Cerbat districts; large quantities were found in upper levels of Stockton Hill district; mined at Minnesota-Connor, Golden Star, and Paymaster mines. Yavapai County, in silver ores of Bradshaw Mountains.

Pyrite (iron sulphide). Common and widely distributed, generally in close association with copper sulphides. Cochise County, with copper ore of Bisbee, Copper Queen, Calumet & Arizona, and other mines. Gila and Pinal counties, abundant in unenriched parts of nearly all copper deposits near Globe, Miami, and Ray. Greenlee County, important ore of Clifton-Morenci district; large masses in Joy, Ryerson, Morenci, and other mines. Mohave County, primary ore of Chloride, Mineral Park, and Cerbat districts; mined at Tennessee, Schuylkill, Keystone, Windy Point, Vanderbilt, and Idaho mines; carries gold values. Pima County, important ore in Mammoth mine; also in Leader and Ridley mines. Santa Cruz County, in granite at Providencia Canyon, 5 miles west of Washington; also at Duquesne. Yavapai County, in ores of Bradshaw Mountains, carries free gold; also with chalcopyrite and sphalerite mined at United Verde mine, Jerome district, for copper, gold, and silver.

Pyrolusite (black oxide of manganese). Cochise County, at Tombstone, mined for silver content only; formerly used for flux. Greenlee County, in Clifton-Morenci district; mined for flux. Yavapai County, secondary mineral in ores of Bradshaw Mountains; unimportant; not mined.

Pyromorphite (phosphate of lead). Occasionally found with other lead ores; occurs in Yuma County, at Iber-Plumosa mine, Bouse; reported in Pima County, at Cerro Colorado mine, and in Santa Cruz County, at Constitution mine.

Pyrope. *See* Garnet.

Pyrrhotite (magnetic pyrite). Yavapai County, in ores of Bradshaw Mountains; mined for gold values.

Quartz. Cochise County, gold bearing; formerly mined at Easter Sunday mine, for use as converter lining.

Quartzite. Greenlee County, quarried for converter lining, near Metcalf, Clifton-Morenci district.

Salt. *See* Halite.

Sand. Widespread and abundant; reported dug for building in Cochise County, 18 miles west of Douglas, and in Mohave County, at Yucca.

Sandstone. Excellent quality in great abundance in many places; as red, brown, so-called blue, and white sandstone of good quality, in Grand Canyon region. Quarried for rough building in Yavapai County, at Kirkland, and 2½ miles northwest of Prescott, and for flagging and rubble in Cochise County, at Douglas.

Scheelite. Cochise County, small quantity in quartz veins cutting granite about 4 miles north of Dragoon. Pinal County, mined for gold and silver content at Maudina mine, Old Hat district, Santa Catalina Mountains. Santa Cruz County, small quantity mined as tungsten ore with wolframite, 7½ miles north of Nogales.

Serpentine. Greenlee County, pure yellow, translucent, west of Morenci; dark-green with magnetite at Thompson mine.

Silver. Large quantities produced generally with various proportions of gold, copper, and lead, at the following places: Cochise County, Tombstone, Herschell, Bunker Hill, Royal Guard, Calumet & Arizona, and Copper Queen mines; Gila County, Old Dominion, Arizona-Commercial, Warrior, Keystone, Globe Consolidated, and other mines; Greenlee County, Detroit, Arizona-Copper, Shannon, Silver King, Gold Bar, Capote, Silver Bonanza, and other mines; Mohave County, Grand Gulch, Bentley district; Gold Road and Tom Reed, San Francisco district; Banner, Champion, and Tennessee, Wallapai district; Pima County, Pima and Silver Bell districts; Yavapai County, Big Bug, Martinez, Tiger, Verde, and Walker districts. Small quantities of silver are produced in Pinal, Santa Cruz, and Yuma counties. *See also* Argentite, Cerargyrite, Dyscrasite, Embolite, Freieslebenite, Polybasite, Pyrargyrite, and Stromeyerite.

Silver (native). Native silver in beautiful specimens has been found in Gila County in a placer 12 miles north of Globe; in Pinal County, at Silver King mine; in Yavapai County, at McMillanville, at the Tiger mine; and in other counties.

Slate. Maricopa County, fair grade of roofing slate, bluish gray, 6½ miles north of Phoenix; undeveloped.

Smithsonite (zinc carbonate). Greenlee County, in Shannon Mountain, Clifton-Morenci district; unimportant.

Specularite. *See* Hematite.

Sphalerite (zinc blende). Cochise County, Tombstone district. Greenlee County, accompanies copper ores in Clifton-Morenci district. Mohave County, occurs in Chloride district, Tennessee and Towne mines; Mineral Park district, Keystone mine; Cerbat district, Vanderbilt and Flores mines; Stockton Hill, Union Pass, and Golconda districts. Pima County, occurs with silver ores at Mammoth and many other mines and with copper ores at Ridley mine. Pinal County, Globe district, Bobtail mine, on north side of Mineral Creek. Santa Cruz County, occurs at many mines; shipped from Patagonia district. Yavapai County, common in Bradshaw Mountains district; carries free gold at Crown King and other mines, and gold and silver at United Verde mine, Jerome district.

Stibnite (sulphide of antimony). Mohave County, in Cerbat district, at Vanderbilt mine. Yavapai County, common in silver veins; in ores of Bradshaw Mountains carries free gold; mined.

Stromeyerite. Pinal County, Silver King mine, with other cupriferous and argentiferous ores.

Tenorite. Cochise County, unimportant copper ore; occurs in Lowell and Copper Queen mines, Bisbee, and elsewhere.

Tetradymite (telluride of bismuth). Yavapai County, small quantity in Montgomery mine, at Minnehaha, and near Bradshaw City.

Tetrahedrite (gray copper). Pinal County, Heintzelman and Silver King mines. Santa Cruz County, Tyndall district, Alta mine, Treasure Vault mine, and others. Yavapai County, in ores of Bradshaw Mountains district; also in copper-silver veins.

Thenardite (verde salt). Yavapai County, Verde Valley, 3 miles southwest of Old Camp Verde, occurs in large beds with rock salt, glauberite, and mirabilite.

Tungsten minerals. *See* Hübnerite, Scheelite, and Wolframite.

Turquoise. Cochise County, near Gleason; has been mined at Turquoise Mountain. Maricopa County, occurs 12 miles east of Morristown. Mohave County, several mines worked near Mineral Park yield large quantities of gem material.

Vanadinite. Occurs at numerous places associated with lead ore: Cochise County, near Fairbanks; Gila County, Globe district, at Lockwood claim, Clark & Stewart claims near Old Dominion mine; Pima County, Old Yuma mine, 14 miles northwest of Tucson; Pinal County, Mammoth mine at Schultz, Royal Dane claim, 7 miles southwest of Oracle, Black Prince mine, Pioneer district, and at Kelvin; Yavapai County, near Silver Belt mine, Big Bug district; Yuma County, Red Cloud mine.

Vanadium ores. *See* Descloizite, Vanadinite, and Volborthite.

Verde salt. *See* Thenardite.

Volborthite (vanadate of copper). Occasionally met with in other copper and lead ores.

Wad (manganese ore). Cochise County, occurs at Tombstone; mined for silver content only.

Willemite (silicate of zinc). Greenlee County, small grayish crystals in Modoc open cut on Modoc Mountain, Clifton-Morenci district.

Wolframite (tungstate of iron and manganese). Cochise County, Whetstone Mountains, 12 miles south of Benson; Maricopa County, Cave Creek, 30 miles north of Phoenix; Mohave County, 80 miles southeast of Kingman in Aquarius Mountains, mines 17 miles east of Yucca; Pima County, with gold and quartz in Arivaca district; Santa Cruz County, 7 miles north of Nogales; Yavapai County, Tip Top mine, Bradshaw Mountains.

Wood (silicified). Apache County, large quantities obtained at Adamana and cut for ornamental purposes.

Wulfenite (molybdate of lead). Occasionally found with other lead ores; nearly always present with silver ore of Tombstone, Cochise County, in small quantity; occurs also in Gila County, at Troy; Pima County, Old Yuma mine, 14 miles northwest of Tucson; Pinal County, Mammoth mine, Schultz; Yavapai County, Bradshaw Mountains; Yuma County, at Castle Dome.

Zinc. Principal production of zinc in the State is in Mohave County; small quantity in Santa Cruz. *See also* Smithsonite, Sphalerite, and Willemite.

ARKANSAS.

Agate. Montgomery County, finely variegated; has been mined.

Antimony ore. *See* Stibnite.

Asphalt. Pike County, in Lower Cretaceous sandstones (Trinity sand), 2½ miles southeast of Pike City; has been used to a small extent. Also occurs in Madison County.

Azurite (blue carbonate of copper). Searcy County, copper mines at Tomahawk; not worked as ore.

Barite (heavy spar). Montgomery and Polk counties, in seams or pockets.

Bauxite. Pulaski and Saline counties, in area 20 miles long and 5 to 6 miles wide, south and southwest of Little Rock; principal producing area of United States in 1912.

Braunite (manganese ore). Independence, Izard, and Sharp counties, mined with psilomelane in Batesville district.

Brown iron ore. *See* Limonite.

Calamine (zinc silicate). Lawrence County, in Bath and Koch mines. Marion County, in zinc mines of Sugar Orchard region; has been mined.

Celestite (strontium sulphate). Pike County, occurs at White.

Cement material (Portland). Little River County, large cement plant at Whitecliffs. Limestone suitable for Portland cement occurs in many counties in northwestern part of the State.

Cerusite (lead carbonate). Howard County, with galena and coating it in mines in northern Arkansas.

Clay (brick). Ashley County, alluvial clay used at Hamburg. Arkansas County, common brick made from red surface clay at Stuttgart. Benton County, pits at Bentonville, Rogers, and Siloam Springs. Boone County, at Harrison. Bradley County, at Warren. Clark County, at Gurdon. Clay County, at Pratt. Cleveland County, pressed brick made at Kingsland. Columbia County, surface clays used at Magnolia and Waldo. Craighead County, common and pressed brick made at Jonesboro. Cross County, loess and surface clay used near Wynne. Drew County, alluvial clays used near Monticello. Faulkner County, buckshot clays used at Conway. Greene County, loess used at Paragould and Gainesville. Hempstead County, surface clay used at Hope, Doyle, and Spring Hill. Hot Spring County, alluvial clay used for common and pressed brick at Malvern; white plastic for white front and paving at Malvern. Howard County, at Nashville. Jefferson County, alluvial and surface clays used at Pine Bluff and Redfield. Lawrence County, white surface clay used at Walnut Ridge; yellow or reddish clay at Black Rock, residual clay at Imboden. Lee County, red brick from loess of Crowleys Ridge at Marianna. Lonoke County, at Lonoke and Cebat, red surface clays used. Miller County, Tertiary clays used at Texarkana for pressed and common brick. Mississippi County, alluvial clay used for common brick and tile at Blytheville. Monroe County, at Brinkley. Nevada County, at Emmet and Prescott, common brick and building tile. Phillips County, loess used at Helena. Poinsett County, reworked loess used at Harrisburg, common brick and draintile. Pope County, residual clay and shale used at Mena and Atkins. Prairie County, red surface clay used at Devall Bluff. Pulaski County, surface clay used at Little Rock. Randolph County, at Pocahontas, common and front brick. St. Francis County, brick clay and yellow loess on and near Crowleys Ridge, burns solid red; mined at Forrest City. Saline County, surface clays used at Benton. Sebastian County, Carboniferous shales used at Fort Smith and Mansfield for common and paving brick; alluvial clay near Fort Smith, burns bright red, soft brick, repressed for front brick, uniform good color. Union County, red surface clay used at Felsenthal. Washington County, at Prairie Grove, common brick and drain tile. White County, argillaceous shales of Round Mountain suitable for sewer pipe and paving brick; surface clay mined at Beebe, Searcy, and Judsonia. Woodruff County, surface clay used at Cotton Plant. Yell County, alluvial and surface clay, mined at Dardanelle.

Clay (fire). Crawford County, disintegrated Carboniferous shales in vicinity of Van Buren; make good yellow ware; used to line kilns at Fayetteville; occurs also in Dallas, Hempstead, Pike, Sebastian, and White counties.

Clay (kaolin). Dallas County, white kaolin of fair refractoriness outcrops on Kilmer land. Ouachita County, in large quantity on Sandy Branch. Pike, Pulaski, and Saline counties, beds of variable color on Vaughn Creek. Pulaski County, white pisolitic kaolin in various places in Fourche Mountain region, burns white, glazes well.

Clay (pottery). Ashley County, Tertiary clays suitable for common pottery near Hamburg. Bradley County, near Alga Bluff, Crawfords Bluff. Calhoun County, supply on Champagnolle Creek, Moro Creek, and large streams. Cleveland County, near New Edinburg, Mount Elba, etc. Columbia County, near Mount Holly and Magnolia. Dallas County, abundant and excellent quality along streams. Faulkner County, buckshot clays, abundant over flood plains of streams. Franklin County, strong dark-red earthenware, residual clays abundant. Hempstead County, Tertiary clays used for jug ware, etc., at Spring Hill. Hot Spring County, at Perla switch, near Malvern, burns light cream common pottery. Jefferson County, white Bluff on Arkansas River. Johnson County, soft shale sagger clay in Felker mine, Coal Hill. Lafayette County, leached pottery clays along Red River. Logan County, Pennsylvanian clay abundant. Miller County, Tertiary clays used at Texarkana for jugs, churns, and jars; burns solid cream colored. Ouachita County, abundant along Ouachita Valley. Pulaski County, red and yellow surface clay used in Little Rock district for making flower pots. Saline County, Tertiary clays used for jugs, crocks, jars, etc., at pottery near Benton. Sebastian County, red and blue has been mined in NE. ¼ sec. 20, T. 10 N., R. 26 W.; abundant at Fort Smith and elsewhere; light yellowish surface clay used at Comby's pottery. Union County, abundant. Yell County, Carboniferous shale formerly used in SE. ¼ sec. 12, T. 6 N., R. 21 W.

Coal. Arkansas coal varies from bituminous to semianthracite; coal-bearing rocks belong to Pennsylvanian (upper Carboniferous); three beds worked, Hartshorne, Charleston, and Paris; Hartshorne most important. Crawford County, Charleston coal, 9 to 18 inches on north side of river near Alma, semibituminous, mined. Franklin County, Paris coal mined at Potato Hill; west of Potato Hill worked for local supply. Franklin and Johnson counties, Coal Hill, Denning district, Hartshorne coal 1 to 5 feet thick; mined from Coal Hill to Denning; semibituminous. Johnson County, Spadra district, Hartshorne coal, 3 feet thick, mined near Spadra, anthracite; Philpot district, Charleston coal 18 to 22 inches, mined at Ozark, semibituminous. Logan County, Paris seam 2 to 3 feet, mined in vicinity of Paris; semibituminous. Pope County, Russellville district, Hartshorne coal 40 to 46 inches in Shinn Basin, mined; semianthracite. Scott County, Hartshorne coal 4 feet in Bates-Coaldale district; mined near Bates. Sebastian County, Bonanza-Jenny Lind district, Hartshorne coal 3 to 6 feet; also 2 to 6 feet in Greenwood-Huntington district. Charleston bed outcrops between Charleston and Fort Smith, mined near Central, 20 inches thick. Yell County, Atoka coal 1½ to 3 feet thick in vicinity of Dardanelle; has been mined. *See also* Lignite.

Copper ore. *See* Azurite.

Diamond. Pike County, two peridotite dikes near Murfreesboro; white, brown, and yellow stones; more than 1,200 found.

Fuller's earth. Area of about 3 square miles between Hot Springs and Benton; 2,563 tons produced in 1910. Only two plants operating in 1911, at Fairplay and Klondike.

Galena. Has been mined in northern Arkansas fields, in Benton, Carroll, Boone, Marion, Washington, and other counties. In western Arkansas it has been found sparingly and mined occasionally in: Garland County, small crystals occasionally found in quartz near Blakely Creek; Montgomery County, in quartz at Rubicon mine, near Virginia City, and at Waterloo mine; Pulaski County, Kellogg mines; Sevier County, New Discovery shaft, near Conboy, and elsewhere.

Gas, natural. *See* Natural gas.

Gypsum. Pike County, was mined at Tokio.

Greenockite. Marion and other counties; occurs with sphalerite.

Hydrozincite (zinc carbonate). In zinc and lead regions, Baxter, Lawrence, Marion, and Searcy counties.

Kaolin. *See* Clay.

Lignite. Beds, possibly of workable thickness, underlie parts of several counties south and southwest of Little Rock; workable beds near Camden, Ouachita County.

Limestone (building). Carroll County, quarried at Eureka Springs; Independence County, oolitic limestone, ornamental, has been quarried at Batesville; Izard County, quarried at Guion; Lawrence County, quarried at Imboden, for building and crushed stone.

Limestone (hydraulic). Occurs in Saline County, and many counties in northern part of State; not used.

Limestone (lime). Benton County, quarried and burned near Rogers; Montgomery County, Cedar Glades; Stone County, east of Sylamore; Washington County, Farmington, Johnson, and elsewhere.

Limonite. Small quantity in nearly every county; has been mined near Berryville, Carroll County.

Magnetite (magnetic iron ore). Hot Spring County, in loose fragments at Magnet Cove; not mined.

Manganese ore. *See* Psilomelane, Pyrolusite, Wad.

Marble. Marble region includes Benton, Boone, Marion, and parts of Baxter, Independence, Izard, Searcy, Stone, and Washington counties. Marbles and limestones belong to the Mississippian series and the Ordovician system of rocks.

Marble (black). Fine black, suitable for ornamental purposes at Jamestown, in southern part of Independence County; reported shipped.

Marble (gray). Gray (Boone limestone), finest quality in Boone, Marion, Newton, and Searcy counties; coarsely crystalline; good polish.

Marble (onyx). Onyx marble in numerous caves and through limestone in northern Arkansas.

Marble (oolitic). Independence County, oolitic marble quarried near Batesville, for monuments.

Marble (St. Clair). Light gray to chocolate-brown, highly crystalline, 2 to 4 feet thick in irregular belt running across central part of northern Arkansas in east and west direction from Hickory Valley, Independence County, to Mount Hersey, Newton County; valuable building stone.

Marble (St. Joe). Widely distributed north of Boston Mountains. Light pink to dark chocolate, spotted white, gray, or pea-green, varies in texture; in Buffalo River and Crooked Creek basins in Newton, Boone, Carroll, Marion, and Searcy counties.

Marl. Calcareous and shell marls in Clark, Greene, Hempstead, Jefferson, Lonoke, Madison, Pike, and St. Francis counties; gypseous marls in Greene and Pike counties; have been mined.

Mica (muscovite). Hot Spring County, Magnet Cove; not mined.

Natural gas. One hundred and ten productive wells in State in 1911, all near Fort Smith.

Niter (saltpeter). Occurs in niter earth of limestone caves of northern Arkansas, Marion, and Newton counties; not mined.

Novaculite. White novaculite forms ridges in Hot Spring, Garland, Howard, Montgomery, Pike, Polk, Pulaski, and Saline counties; many quarries. Whittington's on Quarry Mountain ships to all parts of country; used by engravers, surgeons, etc.; also for wheels, and for finishing and polishing powder. Called Arkansas stone and Washita stone.

Oilstone. *See* Novaculite.

Phosphate rock. Independence County, mined near Batesville; occurs near Hickory Valley, 12 miles north of Batesville. Searcy County, Garvin tract, near St. Joe.

Psilomelane (manganese ore). In the manganese mines of Batesville district, Independence, Sharp, and Izard counties; occurs with pyrolusite in novaculite in belt extending from Pulaski County, through Saline, Garland, Hot Spring, Pike, Montgomery, and Polk counties.

Pyrolusite (manganese ore). Important ore of manganese; in small quantities with psilomelane in Pulaski, Saline, Garland, Hot Spring, Pike, Montgomery, and Polk counties; has been mined at Cushman, Independence County; and near Little Rock, Pulaski County.

Quartz. Hot Spring County, clear crystals at many localities; used for ornaments and lenses; smoky quartz in small quantities about Magnet Cove, used for jewelry; Madison County, clear, limpid quality at Delaney; Montgomery County, crystals have been mined near Crystal Springs.

Reddle (red chalk). Abundant in many localities; probably useful in paint manufacture; not mined.

Rutile. Hot Spring County, abundant in several places about Magnet Cove, often with brookite; not mined; good museum specimens.

Sand (building). Dug at many places: Boone County, Harrison; Clark County, Arkadelphia; Greene County, Paragould; Izard County, Guion; Jefferson County, Pine Bluff; Pulaski County, Little Rock; Saline County, Benton; Sebastian County, Fort Smith.

Sand (glass). Dug in Izard County, at Guion; Jefferson County, in small quantity at Pine Bluff; St. Peter sandstone along valley of White River from Batesville nearly to Fayetteville, probably will make excellent glass sand.

Sand (molding). Johnson County, brown sandy loam suitable for molding sand in vicinity of Coal Hill; Pulaski County, dug at Little Rock.

Sandstone (building and crushed stone). Quarries are located at the following places: Benton County, Siloam Springs; Boone County, Alpena Pass; Cleburne County, Heber; Conway County, Morrillton; Garland County, Hot Springs; Independence County, Batesville; Johnson County, Clarksville; Polk County, Eagleton, near Mena; Sebastian County, Greenwood; Washington County, Fayetteville; White County, Bald Knob and Russell; and Yell County, Dardanelle.

Silver. Pulaski County, in galena, chalcopyrite, and sphalerite in Kellogg mines; Sevier County, with lead ores in Stewart lode near Antimony City.

Slate. Gray, black, green, and red slates along uplift west of Little Rock; slate area includes parts of Saline, Garland, Montgomery, and Polk counties. Garland County, worked in small way at several points near Hot Springs; not shipped at present. Montgomery County, dark red quarried for switchboards at Slatington. Polk County, several quarries; Missouri Mountain slate, red and green, suitable for laundry tubs, wainscoting, switchboards, extensively prospected near Board Camp Creek; slate, blue to black, in Stanley shale, extensively prospected in southeastern part of county.

Smithsonite (zinc carbonate). Most valuable and next to sphalerite most abundant ore of zinc in Arkansas; "turkey fat," a cadmiferous variety of smithsonite, mined in limited quantity.

Soapstone. *See* Talc.

Sphalerite (zinc blende). Most important and abundant zinc mineral in northern Arkansas; in Boone County mines; Lawrence County, calamine and smithsonite in Bath and Koch mines; Marion County, in limestone at Wood's mine; Pulaski County, Kellogg mines; and mines in Saline, Sevier, and Sharp counties.

Stibnite (antimony sulphide). Sevier County, was mined for silver in Bob Wolf mine; also found in Pike County.

Sunstone. Hot Spring County, pink or gray, occasionally found in Magnet Cove; cut for ornaments.

Syenite. Hot Spring County, elæolite syenite quarried at Diamond Jo quarry in Magnet Cove region; suitable for ornamental interior use. Saline County, occurs in large masses, light gray, pinkish, or buff; quarried.

Talc (soapstone). Pulaski County, at Wallis's soapstone quarry. Saline County, has been quarried between Little Rock and Hot Springs; no production in 1911.

Tripoli (polishing powder). The porous siliceous residue resulting from decay of siliceous limestone occurs in zinc region. Montgomery County, T. 4 S., R. 26 W., reported good quality. Marion County, reported abundant at Lees Mountain; not used. Occurs as decomposed novaculite in Hot Spring, Garland, Montgomery, Polk, Pike, and Howard counties.

Variscite. Montgomery County, translucent and transparent, emerald to bluish green; not mined.

Vesuvianite. Hot Spring County, yellowish-green to olive-green crystals in Magnet Cove; not mined.

Wad (bog manganese). Izard County, north fork of White River. Marion County, about Dodd City; unimportant. Common but of no particular value in northern Arkansas.

Whetstone. *See* Novaculite.

Zinc. In plateau portion of Ozark uplift, including parts of Baxter, Boone, Marion, Newton, and Searcy counties; mines scattered; deposits chiefly in Ordovician rocks. *See* Smithsonite and Sphalerite.

CALIFORNIA.

Agalmatolite (pyrophyllite). San Diego County, near Encinitas.

Agate, moss. San Bernardino County, jaspery agate in San Bernardino Mountains, not mined.

Alabaster. Riverside County, in Palen Mountains; San Luis Obispo County, at Arroyo Grande; Santa Barbara County, has been mined at Point Sal, occurs in eastern part of county.

Alum salts. *See* Kalinite.

Alunite. Mariposa County, occurs in Tres Cerritos Buttes, southwest of Indian Gulch.

Amalgam. Mariposa County, gold amalgam quoted by Dana.

Amblygonite. San Diego County, was mined at Stewart mine near Pala.

Andalusite (chiastolite). Madera County, fine specimens at Daulton; Mariposa County, Moores Hill, and on Chowchilla River; Riverside County, opaque pink at Cahuilla.

Anglesite. Inyo County, found in oxidized zone of Cerro Gordo mines.

Anhydrite. Shasta County, Rising Star mine.

Antimony. Kern County, has been mined in San Emigdio Canyon, and near Havilak; Riverside County, occurs near Corona. Is obtained in antimonial lead as a by-product in smelting gold-lead-silver ores of the State. *See also* Stibnite.

Apatite (asparagus stone). San Bernardino County, east end of Kingston Range; San Diego County, Dos Cabezas mine near Jacumba; not mined.

Apophyllite (fish-eye stone). Plumas County, white to gray at Buckeye mine near Orion Valley; San Francisco County, found rarely at Fort Point; San Mateo County, near La Honda; Santa Clara County, at New Almaden quicksilver mines.

Arsenic. *See* Arsenopyrite.

Arsenopyrite. Kern County, mined for gold in Sunshine and La Crosse mines southeast of Randsburg. Placer County, common in Ophir gold-silver veins. Madera County, often associated with coarse gold as at Gambetta mine; Sierra County, Fightner mine, and in many mines of the Mother Lode. Common in gold mines of East Lode.

Asbestos (chrysotile). Reported from northwestern border of serpentine belt extending from Plumas County south through Sierra, Nevada, Placer, Amador, and Calaveras counties; prospects; was mined in Butte and Riverside counties, and near Auburn, Placer County.

Asphalt and bituminous rock. Considerable deposits of asphaltic sandstone in following counties: Kern County, in the McKittrick and Sunset oil fields; Mendocino County, near Point Arena; Monterey County, southeast of Metz, northeast of King City, west of San Ardo, and west of Bradley; San Luis Obispo County, south of San Luis Obispo; Santa Barbara, along the coast west and east of Santa Barbara, and in the Santa Maria district in the Casmalia Hills, on Graciosa Ridge, east of Sisquoc, and in the Purisima Hills; Santa Cruz County, north of Santa Cruz; Ventura County, in the Ojai Valley. Also numerous small deposits of maltha and asphalt scattered through the Coast ranges.

Axinite. Eldorado County, Consumnes copper mine near Fairplay; Inyo County, occurs at several places in Death Valley; Riverside County, in quarry near Riverside; San Bernardino County, Funeral Range and Owl Mountains; San Diego County, mined near Bonsall.

Azurite (blue carbonate of copper). Eldorado County, with other copper ores in Alabaster Cave mine near Newcastle; Inyo County, in Ubehebe district. Also in copper ores in Calaveras, Modoc, Monterey, San Bernardino, and Shasta counties.

Basalt. Used extensively for road metal.

Bauxite. Riverside County, near Riverside; Yuba County, 2 miles southeast of Smartsville, white and red.

Benitoite. San Benito County, in southeastern part, 35 miles northwest of Coalinga; associated with serpentine.

Bentonite. Kern County, 4 miles north of Randsburg.

Beryl. San Diego County, aquamarine variety mined intermittently at Pala, Rincon, Mesa Grande, and Ramona.

Bismuth. San Bernardino County, southeast of Banning, in veins; San Diego County, Pala, Rincon, in pegmatite.

Bismutite. San Diego County, Pala, Rincon, in pegmatite.

Bitumen. *See* Asphalt.

Bloodstone. San Bernardino County, south end of Brown Mountain, Death Valley region, cut for gems.

Borax. Has been produced from the waters of Borax and Hachinhama lakes in Lake County. Deposits of the marsh type were formerly extensively worked at numerous localities in Inyo, Kern, and San Bernardino counties. Deposits of the calcium borate mineral, colemanite (which see), are now being worked in Ventura, Los Angeles, and Inyo counties, and similar deposits have formerly been worked in San Bernardino County. *See* Colemanite and Ulexite.

Bornite. Del Norte County, with other copper ores in Low Divide district; Eldorado County, mined at Cosumnes copper mine and Pioneer mine; occurs at Alabaster Cave and Pioneer mines; Nevada County, Mineral Hill, California mines; Shasta County, Bully Hill, Afterthought mines; Plumas County, Shoofly and Peters mines; San Bernardino County, occurs at Tiptop mine, Lava Beds district.

Brown iron ore (limonite). Calaveras County, common in mines southeast of Campo Seco, near Valley Spring, Esmeralda, and Murphy; Placer County, has been mined with magnetite at Hotaling iron ore deposits 6 miles north of Auburn; Riverside County, San Bernardino County, prospects in Cave Canyon area north of Scott Station, at Eagle Mountain, and near Dale; San Luis Obispo County, occurs in secs. 1 and 6, T. 31 S., Rs. 10 and 11 E., and in Jurassic shale and limestone in Perfumo Canyon about 5 miles south of west from San Luis Obispo; Shasta County, with magnetite in numerous prospects, at Gossan, Iron Mountain, near Keswick; mined as iron flux for Bully Hill smelter; Siskiyou County, occurs in sec. 10, T. 46 N., R. 10 W.

Californite. *See* Vesuvianite.

Calaverite. Calaveras County, Stanislaus mine.

Caledonite. Inyo County, found in oxidized zone at Cerro Gordo mines.

Cassiterite (tin ore, tin stone). Riverside County, small occurrence in Cajalco mine, 7 miles east of Corona, in tourmaline rock; San Diego County; found at Pala, of mineralogic importance only.

Celestite. San Bernardino County, occurs near Silver Lake.

Cement material (Portland). Seven Portland cement companies are operating in the State at the following places: Contra Costa County, Cowell, using travertine and shaly clay; Kern County, Monolith, using limestone and clay; San Bernardino County, Colton, using marble; Napa County, Napa Junction, using two grades of limestone; Riverside County, Riverside, using limestone and clay; Santa Cruz County, Davenport, using crystalline limestone, clay, and diatomaceous shale; Solano County, Cement, near Suisun, using travertine and clay.

The principal deposits of suitable material are in the following places: Contra Costa County, travertine from Mount Diablo to Pinole; Kern County, limestone at Tehachapi; Los Angeles County, shell limestone near Mission San Fernando; San Benito County, limestone west of Hollister; Orange County, shell limestone at San Fernando and on mesa toward Orange and toward San Juan; San Diego County, chalklike limestone near Pacific coast at Jamul; Santa Cruz County, limestone near the coast in vicinity of Santa Cruz associated with shale and clay; Shasta County, limestone in abundance in the copper-bearing district, east of Furnaceville, Brock Mountain, north of Lillienthals, near Kennett, and elsewhere; Solano County, travertine from Vallejo to Goodyear; Sonoma County, limestone reported 6 miles northeast of Geyserville on Little Sulphur Creek.

Cerargyrite (horn silver, silver chloride). Placer County, Gold Blossom, California, Mina Rica, and other mines in Ophir region; San Bernardino County, Calico district, and Grapevine mine near Barstow.

Chalcanthite (blue vitriol, sulphate of copper). Alameda County, Leona Heights. Shasta County, was mined at Peck and other mines. Trinity County, with copper and iron ores in New River district.

Chalcedony. Del Norte County, handsome varieties at Pebbly Beach, Crescent City; Fresno County, near Panoche; Kern County, Kane Springs; Los Angeles County, Redondo, in lava near Acton, abundant in rhyolite in Jawbone canyon; Placer County, in gold veins in Ophir district; San Bernardino County, beautiful chalcedony containing vermilion-red cinnabar and resembling St. Stephen stone variety, in granitic rocks near Ash Hill, 15 miles east of Indian Springs; blue chalcedony 38 miles east of Johannesburg and 2 miles east of Leadpipe Spring; San Mateo County, at Pescadero.

Chalcocite (copper glance). Calaveras County, Penn Chemical Co. mines, Campo Seco; Del Norte County, Low Divide district; Inyo County, Bluejay and Sanger mines, Ubehebe district; Mariposa County, Green Mountain mines; Plumas County, Peters and Duncan mines, mined for gold and silver; Shasta County, Afterthought and Bully Hill mines; Tuolumne County, Oak Hill copper mine.

Chalcopyrite (copper pyrites). Calaveras County, Penn Chemical Co. mines west of Campo Seco, said to carry some gold in places, mined for gold and silver in "Foothill Copper Belt"; Del Norte County, Low Divide district; Eldorado County, Alabaster Cave mine, with gold and silver; Fresno County, Fresno copper mine and Copper King mine; Inyo County, Chloride Cliff prospects; Madera County, was mined at Buchanan mine; Mariposa County, Green Mountain mines; Merced County, Jose copper claims, sec. 4, T. 14 N., R. 9 E.; Nevada County, California mine, gold and silver, Spenceville copper mine; Placer County, 2 miles east of Valley View, was worked for gold, was also mined at Hotaling; Riverside County, Vulture Crag, 14 miles east of Capistrano, little gold; San Benito County, Lewis Creek claim, 16 miles from King City; San Diego County, prospects 18 miles east of Encinitas and 12 miles northeast of Lakeside; San Luis Obispo County, near Cayucos, carries gold and silver; Shasta County, mined at Mountain Copper, Bully Hill, Balaklala, and other mines in Shasta district; Siskiyou County, Blue Ledge mine in Elliot district, carries gold and silver; Trinity County, Lambert claims, South Fort district; Tulare County, Tule River, about 20 miles above Porterville; Tuolumne County, was mined at Washington and other mines.

Chromite (chromic iron ore). Alameda County, 15 and 20 miles southeast of Livermore, has been mined at several mines; Amador County, near Jackson and Mount Spring House; Calaveras County, has been mined at Valley Springs, and is found at Campo Seco and Murphy; Del Norte County, found in Rattlesnake Mountain from Bald Hill to Klamath River, French Hill and Low Divide mines; Eldorado County, numerous deposits; Fresno County, has been mined near Sentinel; Glenn County, at Black Diamond mine near Newville; Lake County, in Jerusalem Valley, 8 miles east of Middletown and near Bradford; Los Angeles County, with magnetite near Langs Station, Soledad Canyon; Marin County, 7½ miles west of San Rafael, reported from Maillard Ranch; Mendocino County, several localities in hills west of Russian River Valley; Monterey County, near San Benito River; Napa County, in Pope and Chiles valleys east of St. Helena; Nevada County, near Nevada City, at Washington on Deer Creek, and Coyote Diggings; Placer County, has been mined 2 miles east of Flagstaff Hill, 7 miles east of Iowa Hill, and near Alabaster Cave; Plumas County, 2 miles west of Spanish Ranch and south of Clear Creek, near Meadow Valley; San Benito County, at Emmet and Idria; San Luis Obispo County, near San Luis Obispo, in Santa Lucia Mountains, and near Santa Margarita, and elsewhere; Santa Barbara County, near Santa Ynez; Santa Clara County, near Livermore, San Jose, and elsewhere; Shasta County, deposits have been worked to small extent on Shotgun Creek; Sierra County, occurs along Goodyear Creek and at Howland Flat, near Downieville; Siskiyou County, is found in Forest Mountains and is mined at Chromite Station and Dunsmuir; Solano County, Fairfield; Sonoma County, occurs near Geyersville and Litton Springs, and has been mined at Cloverdale; Tehama County, was mined on north fork of Elder Creek; Trinity County, vicinity of Hayfork and north fork of Trinity River; Tulare County, Deep Creek near Plano and Portersfield; Tuolumne County, northwest of Mountain Pass, about 8 miles southwest of Sonora and elsewhere. Found also in other counties, usually in serpentine areas.

Chrysocolla (hydrous silicate of copper). Eldorado County, with other copper ores at Cosumnes copper mine, sec. 25, T. 9 N., R. 12 E., reported to carry gold and silver; Inyo County, found at Darwin and other places; Mariposa County, John Dias mine, sec. 12, T. 6 S., R. 16 E., carries gold, shipped; Mono County, Goleta mines on Copper Mountain, mined for gold and silver; Plumas County, with copper ores in Engels copper mine, Light Canyon; San Bernardino County, claims in Ord Mountain copper group, Hixon mine near Barnwell.

Chrysoprase. Tulare County; mined at Venice Hill, 10 miles east of Visalia; on Deer Creek, 8 miles southeast of Porterville; near Lindsay; at Stokes Mountain, and other localities. Used for jewelry and ornamental work.

Chrysotile. *See* Asbestos.

Cinnabar. Colusa County, has been mined at Manzanita mine; Contra Costa County, near Mount Diablo; Del Norte County, prospecting on Diamond Creek, near northern boundary of county; Eldorado County, has been mined near Latrobe; Fresno County, Mexican mine in northwest branch of Cantua Creek, also Providential group; Lake County, Abbot mine and Anderson prospects in Mayacmas district; Mariposa County, occurs near Horseshoe Bend; Monterey County, Cholame Parkfield mine, 6 miles from Parkfield, has been mined on Arsenal Creek, east of Table Mountain, and at Table Mountain 13 miles from Parkfield; Dutro mine, in the San Carpojo district; Napa County, Boston Mine, Cathill mine, and other places; San Benito County, New Idria and Stayton mine; Santa Barbara County, was mined at Los Prietos mines; Santa Clara County, New Almaden mine and Guadaloupe mines near Los Gatos; Shasta County, 30 miles northeast of Redding; Siskiyou County, near Oak Bar in northern part of county; Solano County, was mined at St. John mine; Sonoma County, Boston Group, Cloverdale mine, Culver-Baer mine, and various other mines; Yolo County, New England and Harrison mines, Knoxville district.

Clay (brick). Ninety-two operators reported a production of brick and other clay products in 1911 valued at $4,915,866; yards at the following places:

Alameda County, Alameda, East Oakland; Amador County, South Carbondale near Jane; Butte County, Biggs; Contra Costa County, Antioch, Eckley, Point Richmond; Del Norte County, Elk Valley; Fresno County, Fresno and vicinity; Humboldt County, Eureka and Fortuna; Imperial County, Holtville and Inglewood; Kern County, Bakerfield and Kern; Kings County, Hanford; Lassen County, Susanville; Los Angeles County, Garvanza, Long Beach, Los Angeles, and elsewhere; Marin County, McNear and San Rafael; Mendocino County, Ukiah; Merced County, Merced; Monterey County, Salinas; Orange County, Fullerton, La Balsa, and Huntington Beach; Placer County, Lincoln; Riverside County, Corona and Hemet; Sacramento County, Sacramento and Riverside; San Bernardino County, Redland and San Bernardino; San Diego County, San Diego; San Francisco County, San Francisco; San Joaquin County, Roberts Island, Carnegie, and on San Joaquin River; San Luis Obispo County, San Luis Obispo; San Mateo County, South San Francisco; Sonoma County, Glen Ellen and Hilton; Santa Barbara County, Santa Barbara and Santa Maria; Santa Clara County, San Jose, Pleasanton, Mount View, and elsewhere; Shasta County, Anderson and Redding; Solano County, Vallejo; Stanislaus County, Modesto; Tulare County, Milo; Ventura County, Montalvo and Ventura.

Clay (fire). Los Angeles County, has been mined at Palates Ranch; Orange County, mined at Gypsum Switch; Placer County, at Lincoln; Riverside County, at Alberhill.

Clay (pottery). Amador County, white clay mined northwest of Ione, and about Carbondale; Eldorado County, has been mined at Michigan Bar; Placer County, at Lincoln.

Coal (lignite). Alameda County, Corral Hollow, includes area on both sides of divide between Livermore and San Joaquin valleys; Eocene age; has been mined. Amador County, Ione field, 4 miles northwest of Ione, underlies valley between Ione and Carbondale; Miocene age; bed 6 to 24 feet thick, has been mined for local use. Orange County, Santiago Canyon, small beds in Trabucco Canyon mined for local use. Riverside County, Elsinore field, bed 3 to 10 feet thick, has been mined for local use. Trinity County, Hyampom Valley, T. 3 N., R. 6 E., bed 17 feet thick, not mined. Is found in small quantity in several other counties, but not mined.

Coal (bituminous). Monterey County, has been mined in Stone Canyon, sec. 14, T. 22 S., R. 13 E., near middle of Mount Diablo Range; San Benito County, Trafton mine, sec. 21, T. 17 S., R. 10 E.

Cobalt. *See* Erythrite.

Colemanite (borate of lime). Inyo County, mined at Lila C. mine, Death Valley; Los Angeles County, Lang; Ventura County, Griffin; San Bernardino County, has been mined in Calico district, Lone Star, and other places.

Copper (native). Del Norte County, Diamond Creek district; Humboldt County, Horse Mountain district; with other copper ores in Amador, Calaveras, Napa, Plumas, Riverside, San Bernardino, and Shasta counties.

Copper. Copper is the principal metal produced in the following districts: Alameda County, Alma (Leona Heights); Calaveras County, Campo Seco and Copperopolis; Fresno County, Big Dry Creek and Pollasky; Inyo County, Furnace Creek, Gold Belt, Harrisburg, and Ubehebe; Kern County, Rademacher and Woody; Madera County, Buchanan and Daulton; Mariposa County, Green Mountain, White Rock; Nevada County, Spenceville; Plumas County, Genesee Valley and Taylorsville; San Bernardino County, Bullion, Dry Lake, Ivanpah, Kane Springs, Monument Park, Shadow Mountains, Signal, and Stedman; San Diego County, near Encinitas; Shasta County, Afterthought, Bully Hill, Kennett, Keswick; Tehama County, Tom Head; Tulare County, Portersville. It is of subordinate importance in many other districts. *See also* Azurite, Bornite, Chalcanthite, Chalcocite, Chalcopyrite, Chrysocolla, Cuprite, and Malachite.

Corundum. Los Angeles County, in drift at San Francisquito Pass; Plumas County, near Meadow Valley; San Bernardino County, in syenite in western part of county.

Cuprite (red oxide of copper). Calaveras County, mined in Copperopolis; Humboldt County, Horse Mountain district; Mono County, Copper Mountain; Napa County, near St. Helena; San Bernardino County, Ord Mountain copper group; Shasta County, Bully Hill mine.

Diamond. Amador County, at Rancheria and Volcano; Butte County, found at Cherokee Flat; Eldorado County, in auriferous gravels at Webber Hill, Placerville and White Rock; Nevada County, at French Corral, and elsewhere.

Diopside. Pink diopside found near San Francisco, cut for gems. Eldorado County, occurs in limestone and serpentine near Mud Springs and at Consumnes copper mine.

Electrum. Placer County, alloy of gold and silver intergrown with sulphides in Ophir mines.

Erythrite (red cobalt ore). Los Angeles County, Kelsey mine, 4 miles north of Azusa; Mariposa County, Josephine mine, Fremont grant.

Feldspar. Kern County, near Woody; Monterey County, mined at Chualar; San Bernardino County, mined at Saratoga Springs; San Diego County, occurs in quantity at Dehesa and Lakeside; Tulare County, near Porterville and Visalia.

Fluorspar (fluorite). Los Angeles County, Glendora; San Diego County, Palomar Mountain, Oak Grove.

Gabbro (norite). Placer County, dark, coarse-grained, quarried near Penryn, for building stone.

Galena. Inyo County, mined in Cerro Gordo, Chloride Cliff, Darwin, Independence, Lookout, and other districts, argentiferous; Placer County, abundant at Booth, Gold Blossom, and other mines in Ophir region, argentiferous; also in Butte, Mono, Plumas, San Bernardino, and Shasta counties.

Garnet. Calaveras County, almandite occurs at Bald Point, Mokelumne River; Eldorado County, grossularite in copper ore in Rodgers mine in eastern part of county; Fresno County, grossularite, 35 miles east of Selma; Inyo County, with datolite at San Carlos; Plumas County, Good Hope mine; Riverside County, essonite in tourmaline district near Coahuila; San Diego County; essonite mined for gems at Hercules, Lookout, Prospect, Little Three, and Surprise mines in Ramona district.

Gold. Gold is the predominant metal produced in 307 of the 413 mining districts of the State. The annual production of gold is about $20,000,000, of which about $9,000,000 comes from placers.

Gold (lode). The mining districts in which gold derived from lodes is the chief metal produced are too numerous to mention. They can be found in United States Geological Survey Bulletin 507, Mining districts of western United States.

Gold (placer). Gold derived from placers has been the principal metal produced in the following districts, many of which, once great producers, have long been idle: Amador County, Lancha Plana, Middle Bar, Oleta, Pine Grove, and Volcano; Butte County, Bangor, Cherokee, Magalia, Nimshew, and Oroville; Calaveras County, Jenny Lind, Mokelumne Hill, Railroad Flat, and Vallecito; Del Norte County, Crescent City; Eldorado County, Indian Diggings, Newtown, and Pacific; Humboldt County, Blocksburg, China Flat, Hoopa, Klamath, Orick, Orleans, and Weitchpec; Kern County, Goler, Red Rock, and Summit; Los Angeles County, Arrastre Canyon; Mono County, Dogtown Diggings; Nevada County, Lowell Hill, North Bloomfield, and You Bet; Placer County, Damascus and Ralston Divide; Plumas County, Elizabethtown, Laporte, Lights Canyon, Sawpit Flat, and Spanish Ranch; Sacramento County, Folsom; San Luis Obispo County, La Panza; Shasta County, Bayles, Jerusalem Creek, and Redding; Sierra County, American Hill, Brandy City, Church Meadows, Eureka, Indian Hill; Siskiyou County, Cottage Grove, Deadwood, Etna, Forks of Salmon, Gilta, Gottville, Hamburg, Happy Camp, Knownothing, O'Mears, Sawyers Bar, Somes Bar, and Summerville; Stanislaus County, Knights Ferry; Trinity County, almost every one of the 24 mining districts; Tuolumne County, Columbia; Yuba County, Brownsville, Camptonville, Marysville, Smartville, and Wheatland. Placer gold is produced in many other districts, but is subordinate to lode gold or some other metal.

Granite (building). Amador County, quarried 4 miles northeast of Jackson; Eldorado County, Placerville; Fresno County, various shades, blue, gray, and black granite quarried in sec. 13, T. 12 S., R. 22 E.; Madera County, large quarries at Raymond; Nevada County, Grass Valley; Placer County, Loomis Station, Lincoln, Penryn, and Rocklin; Riverside County, Riverside, Temecula, and elsewhere; Sacramento County, Folsom; San Bernardino County, Oro Grande and Victorville; San Diego County, San Diego, Foster, Santee, and Sweetwater; Tulare County, Rocky Point quarry, sec. 8, T. 19 S., R. 27 E.; Tuolumne County, Porterville, Phoenix Lake quarry 7 miles northeast of Sonora.

Granite (crushed stone, paving stone, road material). Alameda County, quarried at Berkeley, Leona Heights, and Newark; Butte County, Oroville; Contra Costa County, Richmond and elsewhere; Humboldt County, Arcata; Imperial County, Hanlon Junction; Los Angeles County, Duarte and Hollywood, and stream bowlders crushed in San Fernando Valley and near Azusa; Marin County, San Rafael; Napa County, Napa; Riverside County, Corona; Sacramento County, Fairoaks and Folsom; San Benito County, Logan; San Bernardino County, Victorville; San Francisco County, San Francisco; Santa Clara County, San Jose; Solano County, Cordelia; Sonoma County, Allison, Santa Rosa, and Sonoma.

Graphite (plumbago, black lead). Mendocino County, has been quarried in sec. 8, T. 12 N., R. 15 W.; Sonoma County, quarried 10 miles south of Healdsburg, for mineral paint; Tuolumne County, Morgan graphite mine near Columbia. Undeveloped deposits near Los Angeles and Santa Cruz and in San Bernardino and Siskiyou counties.

Gypsum. Widely distributed; reported from Butte, Colusa, Fresno, Kern, Los Angeles, Riverside, San Benito, San Bernardino, San Luis Obispo, Santa Barbara, Tulare, and Ventura counties. Quarried in Fresno County, at Coalinga and Mendota; Kern County, near McKittrick, Bakersfield, and Dudley; Los Angeles County, Palmdale and Los Angeles; Monterey County, King City; Riverside County, Corona; San Bernardino County, Amboy; Santa Barbara County, at Casmalia, as alabaster. Occurs, but not quarried: Kern County, near McKittrick and elsewhere in West Side oil field; Kings County, 5½ miles northeast of Dudley; Riverside County, extensive beds in Palen Mountains; San Benito County, efflorescent deposit at numerous places on southwest flank of Temblor Range, east of Carrizo Plain, poor grade.

Halite. *See* Salt.

Hematite (red iron ore). Amador County, large deposit in Ione formation, 2 miles west of Ione, also in Calaveras formation; Eldorado County, Pioneer mine and other places; Madero County, Minarets; Riverside County, Eagle Mountain; San Bernardino County, near Kane Springs, Cima, Silver Lake, and Leastalk, and prospects in Cave Canyon area north of Scott Station; Shasta County, abundant; Sonoma County, large deposit at Noble's ranch. Found in small quantity at various places in Alameda, Alpine, Butte, Del Norte, Inyo, Napa, Nevada, Placer, and Sierra counties.

Hübnerite. Inyo County, reported from Tin Mountain; San Bernardino County, with pyrite and chalcopyrite in quartz veins 5 miles from Barnwell, also near Vontrigger, and at Clark Mountain.

Infusorial earth. Los Angeles County, has been dug on Santa Catalina Island, occurs at Wilmington; Monterey County, has been dug in sec. 4, T. 24 S., R. 10 E., and occurs from Santa Lucia Range to Arroyo Seco; Orange County, occurs on Alisos Creek, south of El Toro; San Benito County, has been dug at San Benito and occurs at Hernandez; San Luis Obispo County, occurs at Rancho Corral de los Mulos, in gulch from Oak Flat to Adelaide; Santa Barbara County, has been dug at Lompoc; Shasta County, occurs at Pit River near Hat Creek.

Iron. Iron ore has been produced in the following districts: Calaveras County, Murphy (Esmeralda); Del Norte County, Low Divide and Rattlesnake Divide; Eldorado County, Flagstaff Hill and Latrobe; Madera County, Minarets; Placer County, Hotaling; San Bernardino County, Cave Canyon, Garlic Spring, Iron Mountain, Kelso, Kingston Range, West Lava Beds, and Owl Holes; San Luis Obispo County, Perfumo Canyon and San Luis Obispo; Santa Clara County, Los Gatos; Shasta County, Baird and Shotgun Creek; Siskiyou County, Gazelle; Sonoma County, Cloverdale, and Geyserville; Tehama County, Newville. *See also* Brown iron ore, Chromite, Hematite, Magnetite, Ocher, Pyrite, and Pyrrhotite.

Jasper. Gem quality, found: Calaveras County, red, brown, and yellow, at Murphy; Los Angeles County, red, white, and bluish, near Acton; Marin County, 1 mile south of Sausalito; Plumas County, west of Meadow Valley; San Francisco County, near Lands End Station; Santa Clara County, reported; Shasta County, near Hart.

Kalinite (alum). Alpine County, efflorescence in Silver Mountain district; Inyo County, Caso Springs; Napa County, Howell Mountain; not mined.

Kaolin. San Bernardino County, occurs near Calico; San Diego County, at Jamul.

Kunzite (lilac spodumene). Riverside County, at Fano mine near Coahuila; San Diego County, lilac and greenish colored crystals have been mined at Pala Chief, Caterina, and Stewart mines near Pala and at the Mack mine near Rincon.

Lapis lazuli. San Bernardino County, north slope of South Fork of Cascade Canyon, 1½ miles east of Hogback Mountain, 12 miles from Upland.

Lazulite. Inyo County, occurs in a vein cutting schist in Breyfogle Canyon, Death Valley. The lazulite is confined to a few patches in the vein which can be traced several miles. Mono County, near Bodie.

Lead. Lead is the predominant metal produced in the following districts: Inyo County, Lookout, New Coso, Russ, Saratoga, Swansea, and Union; Orange County, Trabuco Canyon (very little); San Bernardino County, Silver Lake. It is of minor importance in several other districts in other counties. *See also* Galena.

Lepidolite (lithia mica). Riverside County, found with tourmaline in Coahuila Mountains. San Diego County, has been mined as a source of lithia and for ornamental purposes at Stewart mine near Pala; occurs with tourmaline, kunzite, etc., at Pala Chief, Naylor-Vanderburg, Caterina, Tourmaline King, Tourmaline Queen, and other places near Pala; at the Mack and Victor mines near Rincon; in the gem mines of the Ramona district.

Limestone (building). Well distributed over State, chiefly used for lime. Quarried for building, crushed stone, and road metal. Amador County, 4 miles east of Ione; Modoc County, Cedarville; San Bernardino County, Colton; Santa Cruz County, Santa Cruz; Shasta County, Redding.

Limestone (lime). Burned for lime at: Alameda County, Alvardo; Amador County, near Ione; Calaveras County, Vallecito and Camp Seco, in sec. 20, T. 16 N., R. 5 W.; Colusa County, Manzanita; Contra Costa County, near Concord, Oil Canyon, and near Antioch; Eldorado County, at Marble Valley, New Castle, and other places; Kern County, at Tehachapi, Keene, and Sparda; Monterey County, at Davenport; Riverside County, at West Riverside and San Jacinto; in several places in San Benito County; San Joaquin County, at Carnegie; San Luis Obispo County, near Lomon Pelon, Arroyo Grande, and elsewhere; Santa Barbara County, at Lompoc and Batteravia; Santa Clara County, at Black Mountain, 9 miles from Mount View; Shasta County, at Kennett; Siskiyou County, at Callahan and Gazelle; Tuolumne County, at Sonora; Ventura County, at Oxnard; and at other places in other counties.

Limonite. *See* Brown iron ore.

Linarite. Inyo County, Cerro Gordo mine.

Magnesite. Many deposits scattered along the Coast Range from Mendocino County to Los Angeles, and few along foothills of the Sierra Nevada; deposits generally occur as veins in serpentine. Fresno County, mined at Kings River, 10 miles east of Sanger; Kern County, development work has been done on deposits intercalated with sandstone and shale at Bissell, 11 miles east of Mohave; Napa County, has been mined in Chiles and Pope valleys; Placer County, mined at Iowa Hill; Riverside County, mined at Winchester; San Benito County, development work has been done at the Sampson claims between the forks of Larious Creek in Diablo Range; Santa Clara County, has been mined near Livermore; Sonoma County, has been mined near Cloverdale; Tulare County, is mined at Tule River, 9 miles east of Porterville, and has been mined at Harker deposit, 4 miles northeast of Porterville.

Magnetite (magnetic iron ore). Has been mined: Alameda County, at Cedar Mountain; Los Angeles County, at Russ Station and near Acton (very little); Placer County, 6 miles north of Auburn, in Hotaling district; San Bernardino County, with hematite near Dale; Shasta County, numerous mines and prospects, mined as flux for Bully Hill smelter.

Malachite (green copper carbonate). Eldorado County, occurs in Alabaster Cave and Pioneer mines; Inyo County, Wisconsin and Kingman claims; Los Angeles County, in prospects 23 miles northeast of Acton and 3 miles southeast of Little Rock Creek; Madera County, has been mined at Joe Wagner mine, secs. 2 and 35, Ts. 8 and 9 S., R. 18 E.; Mariposa County, mined with other copper ore in Caven Milling Co. mine; Mono County, has been mined with cuprite in Copper Mountain; Riverside County, has been mined in Homestake group, Mount King, and on other claims; San Bernardino County, mined at Copper World mine with other copper ores, occurs in many places; Shasta County, mined with other copper ores at Bully Hill mine.

Manganese minerals. *See* Psilomelane, Pyrolusite, Rhodonite, and Wad.

Marble. Quarried: Amador County, at Carrara quarry, sec. 29, T. 7 N., R. 12 E.; Butte County, at several places; Calaveras County, Vallecito; Mono County, Topaz; Placer County, at several places; San Bernardino County, several quarries on Slover Mountain, beautiful green brecciated variety 11 miles southwest of Barstow, also east of Oro Grande; Tulare County, dark bluish gray at Porterville, for ornamental and monumental use; Tuolumne County, near Columbia.

Meerschaum. Santa Clara County, has been found in Arroyo de San Jose de Gracia.

Mercury (native). In small and variable quantity in all quicksilver mines. Has been mined in Colusa, Eldorado, Fresno, Lake, Monterey, Napa, San Benito, Solano, Sonoma, San Luis Obispo, Santa Clara, Stanislaus, Trinity, and Yolo counties. *See also* Cinnabar, Metacinnabarite, and Quicksilver.

Metacinnabarite. Has been found: Fresno County, in New Idria mine; Lake County, Baker mine; Monterey County, Cholame Parkfield mine, 6 miles from Parkfield; San Benito County, Picachos mine. Was important ore: Napa County, in Redington mine, Knoxville; Santa Clara County, New Almaden mine; Yolo County, Reed mine.

Mexican onyx. *See* Onyx, marble.

Mica (muscovite). Small sheets have been found: Kern County, at Tehachapi; Lassen County, Susanville; Plumas County, Gold Lake; San Bernardino County, Ivanpah; Ventura County, scrap mica has been mined in secs. 12, 13, and 24, T. 17 N., R. 20 W.

Mimetite. Inyo County, found in Cerro Gordo mines.

Millerite. Common in small quantities in quicksilver mines.

Mineral paint. *See* Ocher and Sienna.

Molybdenite. Kern County, found frequently in gold region near Havilah; Placer County, abundant in small scales in Golden Stag veins in Ophir region; Riverside County, small quantity in granite quarry near Corona; Shasta County, found at Lamoine.

Natural gas. At depths of a few hundred to a few thousand feet in the Tertiary strata in all the oil fields of the State (*see* Petroleum), especially in the Midway field and the Buena Vista Hills, western Kern County, locally used for fuel, for lighting, and for conversion into gasoline, or wasted; Sacramento County, occurs at Sacramento; San Joaquin County, in the Quaternary filling of the San Joaquin and Sacramento valleys, near Stockton; Sutter County, at Marysville Buttes; in Solano County, and elsewhere.

Nickel (native). Reported in minute grains in gravel in several counties, but has not been found in sufficient quantity for mining. *See* Millerite.

Niter. Inyo County, beds in upper part of canyon on both sides of Amargosa River and Willow Creek, and at Tecopah; San Bernardino County, beds in the side of the lower part of Amargosa River canyon, Saratoga, and elsewhere; not mined.

Obsidian. Occurs in regions of Tertiary volcanic rocks; small quantities cut for gem purposes.

Ocher (mineral paint). Has been mined: Calaveras County, near Valley Springs; Napa County, near Calistoga; Nevada County, Spenceville; Riverside County, near Corona; Sonoma County, at Ochre and 10 miles south of Healdsburg; Stanislaus County, Knights Ferry, near Kenglas. Mineral paint occurs in quantity also in Butte, Los Angeles, Placer, Siskiyou, Trinity, and Yuba counties.

Onyx, marble, California onyx, Mexican onyx. Quarried: Glenn County, northwest corner sec. 21, T. 18 N., R. 6 W.; Inyo County, white variegated, yellow and black, between Keeler and Lone Pine, about 5 miles north of Keeler; Kern County, various colors were quarried in sec. 2, T. 9 N., R. 17 W.; Plumas County, large deposits in southwest part of county; San Diego County, gray, black, and white on Coyote Mountain, Colorado Desert; San Luis Obispo County, in sec. 9, T. 32 S., R. 15 E., and 5 miles north of Musick; Siskiyou County, 6 miles south of Berrydale, all colors, principally pure white, in secs. 16, 19, 20, and 21, T. 43 N., R. 12 E.; Solano County, Suisun and Vacaville; Sonoma County, Healdsburg.

Opal. Lake County, transparent variety hyalite has been found 30 miles northwest of Mount Diablo; Modoc County, good opal reported from vicinity of Fort Bidwell; San Bernardino County, in seams, veins, and pockets 25 miles northwest of Barstow, amber yellow and other colors, good stones cut; Siskiyou County, fire opals at Dunsmuir; Tulare County, yellow opal has been found at Yokohl and Venice Hill, near Visalia, and "chrysoprase opal" has been mined with chrysoprase at Venice Hill and near Lindsay.

Petroleum. Petroleum is the most important mineral product of California, the leading State in the 1912 production of oil. The principal districts in order of importance are the Temblor Range district, western Kern County, including the Midway, McKittrick, Maricopa, Sunset, and other fields; Coalinga district, Fresno County; Kern River district, central Kern County; Puente Hills district, Los Angeles and Orange counties; Santa Maria district, northern Santa Barbara County; Los Angeles district in the county of that name; Lost Hills district and Belridge, northern Kern County; Santa Clara River district, Ventura and Los Angeles counties; Summerland district (now small), southern Santa Barbara County. Production in those districts in 1911 was 81,000,000 barrels, value $38,700,000, from about 6,000 wells. Also numerous indications of oil and prospects in Devils Den, Kreyenhagen, and Kettleman Hills districts, Kern, Kings, and Fresno counties; San Emigdio district, southern Kern County; southern San Luis Obispo County; Parkfield and Loneoak districts, and west of Bradley, western Monterey County; San Antonio River district, southern Monterey County; Sargent and Moody Gulch districts, Santa Clara County; western San Mateo County; Vallecitos district, San Benito County; Livermore district, Alameda County; western Contra Costa County; Colusa County; southern Humboldt County.

Petzite. Tuolumne County, Norwegian mine, near Tuttleton, Bonanza and Sugarman mines, Sonara.

Platinum. Was recovered in 1911 at dredges in Butte, Calaveras, Merced, Sacramento, and Yuba counties. A few ounces recovered annually at placers in Del Norte, Humboldt, Siskiyou, and Trinity counties. Found also in black sands of Placer, Plumas, San Bernardino, and Shasta counties; in black sands in Kern County at Kane Springs; Nevada County, at Rough and Ready, and Relief Hill; Riverside County, at Holcomb.

Potash. *See* Niter.

Priceite. *See* Borax.

Psilomelane (manganese ore). Alameda County, near Tesla, and formerly mined on Cedar Mountain, 10 miles east of Livermore; Plumas County, in Calaveras formation, 3 miles southwest of Meadow Valley; Riverside County, in the Maria Mountains, northeastern part of county; not mined.

Pumice. Abundant in Mono, Modoc, Lake, San Diego, and San Francisco counties. Many deposits in the Sierra Nevada counties; not worked. Deposit near San Francisco formerly utilized.

Pyrargyrite (ruby silver). Napa County, associated with quicksilver at Calistoga.

Pyrite. Alameda County, mined at Leona Heights, Oakland, and shipped to acid works; also at Fruitdale; Amador County, with copper ore at Newton mine; Calaveras County, "Foothill Copper Belt," at Campo Seco and Union mine, Copperopolis, carries gold and silver, disseminated in gold quartz veins throughout the country; Eldorado County, Pioneer mine, carries gold and silver, with copper ores; Fresno County, with galena and zincblende in Fresno copper mines, argentiferous; Inyo County, Chloride Cliff district; Kern County, Butte mine, Randsburg quadrangle, mined for gold; Madera County, disseminated in gold quartz veins; Mariposa County, Cavan Mining & Milling Co. mine, and Pocahontas mine, with copper ores; Nevada County, was mined at Spenceville with copper ore at Meadow Lake, and in all gold mines of county; Placer County, abundant in veins of Ophir district, auriferous, also in Dairy Farm district; Shasta County, Mountain Copper, Balaklala, Trinity mines, etc., in copper district, carries gold and silver; Siskiyou County, Blue Ledge in Elliott district, carries gold and silver; Tuolumne County, with copper ores in Oak Hill copper mine, carries gold and silver, also disseminated in gold quartz veins.

Pyrolusite (manganese oxide). Alameda County, Cedar Mountain; Calaveras County, occurs, but is not mined, with quartz in mica schists of Calaveras formation 2 miles northeast of San Andreas; Colusa County, prospects in jasper on east flanks of St. John Mountain, near Little Stony; Marin County, on east slope of mountains north of Golden Gate, west of Sausalito; Placer County, reported from foot of Cape Horn Bluff near Colfax; Plumas County, near Meadow Valley and elsewhere; San Bernardino County, with silver ores; San Francisco County, in veins in jasperoid rock; San Luis Obispo County, was mined 5 miles west of San Luis Obispo; Tuolumne County, 2 miles north of Sonora, and small quantities in auriferous gravel near Columbia.

Pyrophyllite. *See* Agalmatolite.

Pyrrhotite (magnetic pyrite). Del Norte County, has been mined with copper ores in Low Divide district; Fresno County, Fresno copper mines; Mariposa County, Green Mountain mines; Shasta County, with pyrite, chalcopyrite, and zinc in Iron Mountain mine, at Gray Rocks and other copper mines. Common in gold ores in granite of East Lode.

Quartz (cat's-eye). Humboldt County, quartz-actinolite cat's-eyes have been found at Eureka; San Diego County, quartz cat's-eye at Point Loma; San Mateo County, at Pescadero Beach.

Quartz (crystals). Calaveras County, from Green Mountain mine, 2 miles south of Mokelumne Hill; have been shipped to New York and cut for ornamental purposes.

Quartz (rose). Tulare County, 9 miles north of Lemon Cove, and Parson claim, 8 miles southeast of California Hot Springs, near the Kern County line; reported at several other places.

Quicksilver. Quicksilver (mercury) is the predominant metal produced in the following districts: Colusa County, Sulphur Creek; Contra Costa County, Mount Diablo (Ryne); Fresno County, Mexican; Lake County, Baker, Mayacmas, and Sulphur Bank; Monterey County, Dutro and Table Mountain; Napa County, Bella Union, Knoxville, La Joya, and Mayacmas; San Benito County, Central Benito, New Idria, and Stayton; Santa Clara County, New Almaden mine, and Guadalupe mine near Los Gatos; San Luis Obispo County, Adelaida, Oceanic, Ocean View, and Rinconada; Santa Barbara County, Los Prietos; Siskiyou County, Beaver Creek; Solano County, St. Johns; Sonoma County, Guerneville and Pine Flat; Trinity County, Altoona; Yolo County, Knoxville. *See also* Cinnabar and Mercury.

Rhodonite. Plumas County, occurs at Peters near Taylorsville; Siskiyou County, Wheeler prospect, 9 miles north of Happy Camp; Tulare County, near Ward ranch, 3 miles north of Lemon Cave; Tuolumne County, with manganese oxide, 2 miles north of Sonora; and at many other localities.

Road metal (macadam, rubble, and concrete). Various materials have been quarried, as listed below: Alameda County, trap, chert, sandstone, basalt, and jasper; Colusa County, sandstone; Contra Costa County, sandstone, and gravel; Los Angeles County, sandstone; Marin County, sandstone, chert, and siliceous shale; Napa County, tuff; Riverside County, granite, and gneiss; Sacramento County, diorite, and granite; San Benito County, granite; San Francisco County, sandstone; San Joaquin County, chert, and sandstone; Santa Clara County, siliceous shale; Santa Cruz County, limestone; Shasta County, limestone; Solano County, basalt; Sonoma County, basalt; Ventura County, limestone.

Rubellite (red tourmaline). *See* Tourmaline.

Salt. Evaporated from sea or lake water: Alameda County, at Alvarado, Newark, Mount Eden, Oakland, and Russell; Imperial County, Salton Lake, northwest part of county, works no longer exist owing to flooding of Salton Basin; Inyo County, at Owens Lake, Saline, and Salt Wells Valleys; Los Angeles County, Long Beach; San Diego County, La Punta; San Mateo County, Redwood City and Leslie. About 90 per cent of the State's production of salt is made in Alameda County.

Sand (building). Dug in Alameda County, at Centerville and Niles; Contra Costa County, Antioch; Los Angeles County, Los Angeles, Long Beach, and Puente Largo; Monterey County, Lake Majella and Seaside; Napa County, Napa; San Diego County, Coronado, Lakeside, and San Diego; Sonoma County, Healdsburg; Yuba County, Marysville. Sand is dug in small quantity at many other places and occurs in great abundance in dunes along the coast.

Sand (glass). Dug in Alameda County, at Tesla; Los Angeles County, Palmdale; Monterey County, Lake Majella, near Pacific Grove; San Joaquin County, near Stockton.

Sand (molding). Dug in Alameda County, at Centerville and Decoto; Monterey County, Lake Majella; Orange County, Horseshoe Bend; San Diego County, San Diego.

Sandstone. Quarried: Amador County, 6 miles south of Ione; Calaveras County, Valley Springs; Colusa County, near Sites; Contra Costa County, near Martinez; Kern County, 6 miles south of Tehachapi; Los Angeles County, Chatsworth; Marin County, McNear's Point; Monterey County, Tassajara Springs; Napa County, near Monticello, near Napa, and in Maxwell Canyon, 15 miles from Rutherford; Orange County, Santiago Canyon; Sacramento County, along Consumnes River, fine white to yellow, quarried near Michigan Bar; San Bernardino County, in sec. 7, T. 1 S., R. 1 W.; San Luis Obispo County, Arroyo Grande; Santa Barbara County, Santa Barbara, Mission Canyon, Santa Maria, Santa Ynez; Santa Clara County, Graystone, and 10 miles from Los Gatos; Shasta County, secs. 7 and 18, T. 32 N., R. 4 W., and sec. 29, T. 31 N., R. 5 W.; Siskiyou County, Yreka and Henley; Ventura County, near Brownstone; Yolo County, Putah quarry, 9 miles from Winters; and in small quarries at several other places.

Sapphire. Los Angeles County, have been found in drift in San Francisquito Pass.

Satelite (gem stone). Tulare County, variety of serpentine associated with asbestos at Venice Hill; put on the market in 1908.

Scheelite. Kern County, small production from Winnie vein, Stringer district; San Bernardino County, Atolia field, 4½ miles east of Randsburg, largest individual producer in the United States; mixed scheelite and wolframite shipped from vicinity of Nipton.

Serpentine. Amador County, has been quarried 2 miles west of Plymouth, and near Sugar Loaf.

Sienna. Colusa County, secs. 29 and 32, T. 17 N., R. 6 W.

Silver (native). Placer County, Gold Blossom and California mines, Ophir region.

Silver. Silver is the predominant metal produced in the following mining districts: Alpine County, Silver Mountain; Inyo County, Cerro Gordo, Daylight, Deep Springs, Independence, Panamint, and Wildrose; Kern County, Amalie; Mono County, Castle Peak, and Cloverpatch; San Bernardino County, Brightwood, Calico, and Cima. Of minor importance in many other districts. *See also* Cerargyrite, Electrum, Petzite, Pyrargyrite, and Stromeyerite.

Slate. Eldorado County, large quarry roofing slates at Slatington, near Placerville; Mariposa County, has been quarried at Chili Bar, 4 miles north of Placerville, and in sec. 6, T. 6 S., R. 16 E.; Merced County, quarry opened in 1912 about 11 miles east of Planada.

Smithsonite. Inyo County, found in Cerro Gordo mines.

Soapstone. *See* Talc and soapstone.

Soda. Inyo County, mined at Owens Lake; Mono County, occurs at Long Valley Hot Springs, and elsewhere in the county; San Luis Obispo County, at Soda Lake, Carriso Plain.

Sphalerite. Fresno County, with galena and pyrite in Fresno copper mines; Placer County, Moore mines and elsewhere in Ophir region; Shasta County, important ore of Shasta district, rich in gold and silver, Mammoth, Bully Hill, Trinity, and other mines; Siskiyou County, small amount with sulphides and oxides of iron and copper in Blue Ledge mine, Elliott district; carries gold and silver.

Spinel. A few crystals were found in Mack mine, near Rincon, San Diego County, and gems of good quality near San Luis Obispo, San Luis Obispo County.

Spodumene (hiddenite). *See* Kunzite.

Stibnite (gray antimony ore). Found with cinnabar in Colusa County, at Manzanita mine; Kern County, was mined at San Emigdio Canyon; Napa County, at Manhattan mine; Riverside County, near Corona; San Benito County, at Stayton mine.

Stromeyerite. Inyo County, found near Panamint, in Panamint Range; San Bernardino County, has been found at Silver King mine, Calico.

Sulphur. Kern County, at Mariposa; Lake County, has been mined at Sulphur Bank mine; Shasta County, found also in fumeroles near Lassen Butte.

Talc and soapstone. Amador County, has been quarried at Jackson; Shasta County, occurs near Castella; Tulare County, is quarried 8 miles east of Lindsay; occurs in large quantities in Calaveras, Eldorado, Fresno, Kern, Los Angeles, Marin, Nevada, Placer, Tuolumne, and Yuba counties.

Tetrahedrite (gray copper). Inyo County, with malachite and cuprite in Ulida prospects, Ubehebe district; Placer County, with other sulphurets at Boulder, Gold Blossom, Pine Tree, and Golden Stag mines, Ophir region; Shasta County, carries gold and silver in Afterthought mine, Ingot; sparingly in few mines of Mother Lode in Mariposa and Tuolumne counties.

Tin. *See* Cassiterite.

Topaz. San Diego County, mined 2½ miles northeast of Ramona.

Tourmaline. Fine gems, red and pink (rubellite), blue (indicolite), green (Brazilian emerald), and other colors, mined in Riverside and San Diego counties. Riverside County, in the Coahuila Mountains and San Jacinto Range; San Diego County, Himalaya and other mines near Mesa Grande; Pala Chief, Caterina, Naylor-Vanderburg, Tourmaline King, Tourmaline Queen, Stewart, and other mines near Pala; Mack and Victor mines near Rincon; Little Three, Surprise, Hercules, Daggett, and other mines near Ramona.

Trona (carbonate of soda). Obtained at salt lakes in Inyo, Mono, and San Bernardino counties.

Trap rock. Alameda County, quarried at Berkeley, Oakland, and elsewhere, mostly andesite; Butte County, Oroville; Contra Costa County, Richmond; Napa County, Napa City; Sacramento County, Dredge; San Francisco County, San Francisco; Solano County, Cordelia; Sonoma County, Santa Rosa, Mellita, Penn Grove, and Petaluna. *See also* Road metal.

Tufa (calcareous). San Luis Obispo County, quarried at Creston, for fireplaces and furnaces. Has been used locally for making cement in Kern, Mono, Santa Cruz, San Luis Obispo, and Shasta counties.

Tuff. Calaveras County, massive rhyolite tuff has been quarried at Mokelumne Hill, Angels, and elsewhere; Eldorado County, near Placerville; San Luis Obispo County, near Los Bevios; Sonoma County, near Santa Rosa, Sebastopol, and Sonoma; Sutter County, near Sutter City; Tehama County, 20 miles west of Red Bluff, and in sec. 12, T. 24 N., R. 6 W.

Tungsten. *See* Hübnerite, Scheelite, and Wolframite.

Turquoise. Fresno County, Bluish-green turquoise has been found at Taylor's ranch, Chowchilla River; San Bernardino County, about a dozen mines have been worked in the northeastern part of county for gems, ornamental stones, and beads.

Ulexite (borate of lime). Inyo County, occurs at Bennett's Wells at the bottom of Death Valley, Furnace Creek, and elsewhere; Kern County, Cane Springs; San Bernardino County, Cave Springs, Willow Springs Lake, Calico district.

Vesuvianite (californite). Butte County, mouth of Feather River near Oroville; Fresno County, found near Selma and Watts Valley, 32 miles east of Fresno City; Riverside County, Crestmore; Siskiyou County, south fork of Indian Creek, 10 miles west of north of Happy Camp and 90 miles from Yreka; Tulare County, near Exeter and Lindsay.

Verde antique (marble). San Bernardino County, large quarry in sec. 28, T. 7 N., R. 2 W., between Victorville and Barstow.

Wad (bog manganese). Tuolumne County, found in few places in limestone and shale near Columbia.

Wolframite. Madera County, small quantity in tungsten-bearing vein near Raymond; Mariposa County, in quartz vein about 12 miles north of Raymond; San Bernardino County, with scheelite near Nipton, Clark district.

Wood (silicified). Sonoma County, occurs at The Geysers.

Zinc. *See* Smithsonite and Sphalerite.

COLORADO.

Acanthite. Clear Creek County, small quantity with other silver ores; Dolores County, Enterprise mine, Rico.

Agate. Fremont County, mined at Garden Park 7 miles north of Canon City and at Curio Hill 6½ miles south of Canon City. Occurs also at many other places.

Alabandite (manganese sulphide). Park County, Quartzville; Summit County, Queen of the West mine, argentiferous, with rhodochrosite.

Almandite. *See* Garnet.

Altaite (telluride of lead). Boulder County, Gold Hill district, argentiferous and auriferous; has been mined.

Alunite. Custer County, Knickerbocker Hill; Hinsdale County, San Cristobal quadrangle.

Amalgam (natural). Boulder County, several mines; La Plata County, Neglected mine, 15 miles from Durango.

Amazon stone. Douglas County, Devils Head Mountain; El Paso County, Pikes Peak region and Crystal Park near Manitou Springs; Fremont County, near Canon City, in vicinity of Royal Gorge; Jefferson County, Elk Creek; Teller County, 4 miles north of Florissant.

Amethyst. Has been mined at the following localities: Fremont County, 12 miles northwest of Canon City, 1 mile south of Twelve-mile Park; Gilpin County, Nevada; Gunnison County, Elk Mountains; Hinsdale County, Henson Creek; Las Animas County, Animas Range; Mineral County, at Amethyst, near Creede; Saguache County, Carnera Creek.

Anglesite (lead sulphate). Chaffee County, Monarch and Garfield area; Clear Creek County, Georgetown mines; Fremont County, occurs in croppings of Sedalia mine; Hinsdale County, near Lake City; Lake County, in silver-lead mines at Leadville; Ouray County, Red Mountain; Summit County, Breckenridge. Occurs also in many other places.

Antimony. *See* Stibnite.

Aquamarine. Chaffee County, Mount Antero; Clear Creek County, near Georgetown; Fremont County, reported from vicinity of Royal Gorge, 5 miles northwest of Canon City; Jefferson County, near Creswell; Park County, Buffalo Mountain.

Argentite (silver glance). Clear Creek County, Silver Plume and Georgetown mines; Dolores County, Newton Hill mine, Rico district; Hinsdale County, near Lake City; Lake County, silver-lead mines at Leadville; Montrose County, Cashin mine; San Miguel County, Marshall Creek, in quartz veins with tetrahedrite, galena, sphalerite, and some silver; Summit County, Montezuma district. Occurs in many other mines in small quantity all through the Sulphide Belt.

Arsenopyrite (mispickel). Gilpin County, of rare occurrence, sometimes highly argentiferous, but of no great economic value; occasionally auriferous. Gunnison County, near Ruby Camp, with proustite, argentiferous. San Miguel County, Mount Wilson, argentiferous, with tetrahedrite.

Asbestos. Boulder County, Allens Park, Mont Alto Park, etc.; Chaffee County, near Maysville; Fremont County, occurs in Sedalia mine, no production. Rio Grande County, near Jasper.

Azurite (blue carbonate of copper). Fremont County, occurs in Red Gulch copper district; Routt County, Hahns Peak, prospected; San Juan County, occurs in ore bodies of Bear Creek.

Barite. Boulder County, many places in mining area; also vein of considerable size near Boulder. Pitkin County, gangue mineral of Aspen district; common in many veins. San Miguel County, occurs 2 miles north of Placerville in veins 2 to 7 feet wide.

Bauxite. Chaffee County, reported from near Buena Vista.

Beryl. Boulder County, near Glendale. Chaffee County, occurs near top of Mount Antero; color varies from light blue to deep aquamarine green; fine gems, worked intermittently. Clear Creek County, Georgetown. Fremont County, East Gulch, 6½ miles north of Texas Creek; mined, few gems cut. Jefferson County, near Creswell. Park County, Buffalo Mountain.

Bismuthinite (bismuth sulphide). Boulder County, several mines; Chaffee County, occurs at Granite; Grand County, occurs at Cummins City, North Park; Jefferson County, Guy Hill; Lake County, Leadville district, Highland Mary and other mines; La Plata County, California district, Comstock mine; Larimer County, Big Thompson River; Ouray County, Red Mountain district, Indiana mine.

Bornite (peacock ore). Larimer County, occurs at Pearl; Moffat County, with vanadium deposits on Blue Mountain; Montrose County, in ore bodies of Cashin mine; Pitkin County, occasionally found in Aspen district; small quantities of ore found in many other places.

Brochantite. Chaffee County, was mined in Monarch mine.

Brown iron ore (limonite, brown hematite). Mined for flux, also for silver. Fremont County, Sedalia mine; Gunnison County, occurs in irregular masses along Tomichi Creek, Whitepine district; Hinsdale County, occurs near Lake City; Lake County, mined in silver-lead mines at Leadville; mostly manganiferous. Pitkin County, common in Aspen district mines; Saguache County, large body interbedded with limestone at Orient; was extensively worked; still producing few thousand tons annually. Summit County has been mined for flux; occurs in thousands of vein cappings.

Calaverite. Boulder County, several mines; Teller County, mined in Cripple Creek district, at Raven mine, Prince Albert mine, and C. O. D. mines. Principal gold mineral of Cripple Creek mines.

Calciovolborthite. Montrose County, found in crevices in sandstone near Uranium post office. *See also* Volborthite.

Carnotite. Dolores County, reported from points along Rio Dolores; Eagle County, carnotite stains are found on silver and vanadium bearing sandstone on Brush Creek; Moffat County, found on Blue Mountain near Skull Creek, 15 miles north of Rangely, Rio Blanco County; Mesa County, found as an impregnation in sandstone along the Rio Dolores, 40 miles southwest of Gateway; Montrose County, found as an impregnation in sandstone along Roc, La Sal, and Paradox creeks, and in other places; Rio Blanco County, prospects near Coal Creek, 14 miles northeast of Meeker; San Miguel County, near Cedar, along Disappointment Creek, and in adjacent territory, near Placerville in small quantity with roscoelite.

Cement material (Portland). Boulder County (*see also* Larimer County). Fremont County, Mississippian and Cretaceous limestone west and east of Front Range, suitable for Portland cement; cement plants at Portland and Concrete, east of Florence; limestone of Niobrara group used. Larimer County, Niobrara limestone from La Porte to 8 miles west of Longmont, Boulder County, suitable for Portland cement; only very narrow band, 10-20 feet in Niobrara at this point; widens southward into Boulder County. Good limestone occurs at several points in Pennsylvanian east of range and in Carboniferous in Chaffee, Gunnison, and other counties west of range.

Cerargyrite (horn silver). Custer County, Illinois mine, Schanck Hill near Silver Cliff; Eagle County, a silver mineral reported to be cerargyrite occurs in vanadiferous sandstone on Brush Creek; Lake County, common in oxidized ores of silver-lead mines at Leadville; Summit County, occurs near Breckenridge, in small quantities impregnating a rhyolitic rock.

Cerussite (lead carbonate). Clear Creek County, Georgetown area produced considerable quantity; Custer County, has been extensively mined at Silver Cliff; Fremont County, small quantity in Sedalia mine; Hinsdale County, occurs near Lake City; Lake County, mined in silver-lead mines at Leadville; Pitkin County, principal ore of upper zones of Aspen district; Routt County, Hahns Peak region, Tom Thumb mine only producer; occurs also in greater or less quantity with galena ores of Chaffee, Eagle, Summit, and other counties.

Chalcanthite (bluestone). In Clear Creek County and in adjacent parts of Summit County, in considerable quantities in veins, with tetrahedrite, galena, chalcopyrite, sphalerite, barite, etc.; San Juan County, Silver Pick and Special mines.

Chalcedony. Grand County, Willow and Corral creeks, near old salt works, South Park; Park County, Thirty-one Mile Mountain, west of Guffey, blue chalcedony; occurs also at several localities in surface gravels of Gunnison, Logan, Morgan, Ouray, Rio Grande, Saguache, and Weld counties.

Chalcocite (copper glance). Clear Creek County, occurs near Idaho Springs; Chaffee County, near Poncha Springs; Fremont County, Gem mine; Larimer County, occurs at Pearl; Montrose County, rich ore at Cashin mine, La Sal Creek, carries silver; Ouray County, has been mined at Ironton, argentiferous, massive; Routt County, seen at few places; San Miguel County, occurs with siderite and small crystals of sphalerite; argentiferous. Also in sandstone with matrix of calcite (argentiferous); common at other mines.

Chalcopyrite (copper pyrites). Found in small quantities in nearly every camp in Sulphide Belt. Clear Creek County, in mines northwest of Idaho Springs; carries gold and silver. Dolores County, not abundant in Rico district; small amount in Newman, Silver Swan, and other mines. Gilpin County, occurs with uranium in Wood, Kirk, Belcher, and German mines near Central City. Gunnison County, Blistered Horn, Tincup district, Sandy Hook and Gold Links, Gold Brick district, and elsewhere; gold and silver values. Hinsdale County, occurs near Lake City; Larimer County, occurs at Pearl; Pitkin County, Aspen district; Routt County, occurs at Hahns Peak; San Juan County, Monticello lode, Silverton district, carries gold; also in Bear Creek district, carries gold and silver. Summit County, in veins of Montezuma district. Common in other places.

Chrysocolla (silicate of copper). Custer and Saguache counties, Sangre de Cristo Mountains; undeveloped. Jefferson County, Pine Grove and Bear Creek; Lake County, Leadville.

Cinnabar. Boulder County, in small quantity at several points; La Plata County, in sandstone; said to be rich; undeveloped. Several small finds in southern part of State.

Clay (brick). Dug at the following places: Boulder County, Boulder, Trilby; Conejos County, Alamosa; Denver County, Argo and Denver; Douglas County, Parker; El Paso County, Colorado City, Colorado Springs, and Subburbs Springs; Fremont County, Canon City and Florence; Garfield County, Glenwood Springs and Rifle; Hinsdale County, Lake City; Jefferson County, Golden and Hall; Kit Carson County, Burlington; La Plata County, Bell Spur; Larimer County, Fort Collins and Fossil Creek; Las Animas County, Trinidad; Mesa County, Grand Junction; Moffat County, Craig; Montrose County, Montrose; Morgan County, Brush and Fort Morgan; Otero County, La Junta and Fowler; Prowers County, Lamar; Pueblo County, Pueblo; Rio Grande County, Monte Vista; Teller County, Cripple Creek; Weld County, Greeley; Yuma County, Wray and Yuma.

Clay (fire). El Paso County, Colorado City and De Wit Ranch, 4 miles from Colorado Springs; Fremont County, Canon City; Garfield County, plastic clay from Dakota sandstone near Glenwood Springs; has been mixed with crushed quartz and made into bricks for coke ovens at Cardiff; Jefferson County, Golden.

Clay (stoneware). Jefferson County, Golden; burns white, red, and buff.

Coal (anthracite). Gunnison County, mined at Crested Butte; coal-bearing area is about 25 square miles. Pitkin County, has been mined at Crystal City; Routt County, Yampa coal field; small local areas of good coal; not mined yet.

Coal (bituminous and subbituminous). Book Cliffs, Canon City, Durango, Grand Hogback, Grand Mesa, Raton, and South Platte are the principal coal fields.

Book Cliffs field, Mesa and Garfield counties.—There are about 360 square miles of workable, medium grade bituminous coal. The 4 important mines are:

Cameo (8-foot bed), Palisade (6-foot bed), and Book Cliff (7-foot bed), in Mesa County, and Carbonera (7-foot bed), in Garfield County.

Canon City field, Fremont County.—There are about 22,400 acres of high-grade noncoking bituminous coal. The average thickness of beds is 3 to 6 feet. Mining for domestic trade is extensive.

Colorado Springs field, El Paso County.—A good quality of subbituminous coal occurs in 3 beds of 1 to 2 feet in thickness. There are 12 mines in operation.

Danforth Hills field, Rio Blanco and Routt counties.—The workable coal in 10 beds has a minimum thickness of 73 feet. There are about 159,700 acres of workable noncoking bituminous coal. Mined for local use.

Durango field, La Plata and Archuleta counties.—There are 3 beds, 3, 4, and 6 feet thick, of excellent coking bituminous coal, all of which are mined. There are also several workable beds of bituminous coal.

Glenwood Springs field, Garfield and Pitkin counties.—There are 9 beds mined, having a total thickness of about 96 feet. It is a good grade of bituminous coal, noncoking in Garfield County, but coking in Pitkin County.

Grand Hogback field, Rio Blanco and Garfield counties.—There are about 41,720 acres of workable coal land. The 7 beds mined have a total thickness of from 105 to 108 feet. The coal is noncoking bituminous. Mining is rather extensive.

Grand Mesa field, Gunnison, Delta, and Mesa counties.—There are about 550 square miles of workable bituminous coal, some of which is of coking quality. The field is divided into the Palisades district containing 11 feet of workable coal beds, the Rollins district containing 15 feet of workable coal beds, and the Somerset district containing 65 feet of workable coal beds. Of these the Somerset is the most important, producing most of the coal shipped.

Lower White River field, Rio Blanco, Routt, and Moffat counties.—A good grade of bituminous coal is mined in small quantities for local use.

North Park field, Jackson County.—There are about 75,000 acres of possible subbituminous coal land. The 2 beds mined have average thicknesses of 10 and 50 feet. One mine is shipping coal and six are mining for local use.

Raton Mesa (Trinidad) field, Las Animas and Huerfano counties.—About 1,115 square miles of high-grade bituminous coal. There are three series of beds, of which the lower is the most important; average thickness of beds is 6 feet; coal in the southern part of the area is largely consumed in the manufacture of coke. It is the most important coal field in Colorado, producing 62 per cent of the total annual tonnage.

South Park field, Park County.—There are 3 beds 5, 6, and 8 feet in thickness, which were formerly mined; the mines have all been abandoned.

South Platte field (including Denver Basin and Boulder districts).—This field extends from below Denver to near the Wyoming line, covering parts of Douglas, Elbert, Arapahoe, Jefferson, Adams, Morgan, and Weld counties. The coal is of subbituminous grade. Mining is extensive in Boulder County. Beds mined vary from 2 to 15 feet in thickness.

Yampa field, Routt County.—Workable coal area is estimated at 1,200 square miles of bituminous coal. The northern part of the field contains many thick beds of subbituminous grade. The coal is mined for local use at Craig, Hayden, Pool, and Eddy.

Cobalt. *See* Erythrite and Smaltite.

Columbite. Fremont County, near Canon City; Jefferson County, Turkey Creek; Teller County, several points in Pikes Peak region.

Copper (native). Dolores County, California prospect near head of Iron Draw; Jefferson County, near Golden; Montrose County, has been mined and shipped from Cashin mine; Park County, Handcart Gulch; Routt County, in veins near Columbine, Hahns Peak region. Occurs also at many other places.

Copper minerals. Copper is the predominant metal produced in the following districts: Chaffee County, Cleora and Sedalia; Fremont County, Canon City, Cotopaxi, Red Gulch; Grand County, Harmon; Huerfano County, Huerfano (Malachite); Jackson County, Pearl; Jefferson County, Evergreen; Larimer County, Empire and Steamboat Rock; Mesa County, Unaweep; Montrose County, La Sal; Ouray County, Red Mountain; Routt County, Copper Ridge, Elkhorn, Oak Creek, Rock Creek, Spring Creek; Teller County, East Beaver, 8 miles south of Rosemont. Of minor importance in many other districts. *See also* Azurite, Bornite, Brochantite, Chalcocite, Chalcopyrite, Chrysocolla, Covellite, Cuprite, Enargite, Malachite, Melaconite, Tennantite, and Tetrahedrite.

Cordierite. Fremont County, found 6 miles from Canon City.

Corundum. Chaffee County, occurs in crystals at Calumet; Clear Creek County, occurs in Saxon Mountain near Georgetown.

Cosalite. La Plata County, several mines, including Comstock mine near Parrott City; Ouray County, Gladiator and other mines.

Covellite. Montrose County, rich ore at Cashin mine, La Sal Creek; carries silver. Rio Grande County, Summitville; San Juan County, several small finds.

Cuprite. Chaffee County, near Poncha Springs, mined at Lily mine near Garfield. Fremont County, Sedalia mine; Jefferson County, Bear Creek and Pine Grove; Montrose County, occurs in ores of Cashin mine, La Sal Creek; Pitkin County, in oxidized ores of Aspen district. Mined also in many other places.

Cryolite. El Paso County, occurs at St. Peters Dome, Pikes Peak district.

Embolite (chlorobromide of silver). Lake County, near Leadville; of frequent occurrence, chiefly in a siliceous iron ore in cavities and on fissure planes.

Enargite. Clear Creek County, small quantities occur; Gilpin County, has been mined at Russell Gulch, particularly at Powers mine; argentiferous; with pyrite and fluorite. Gunnison County, small quantities in several mines; Ouray County, several mines; Rio Grande County, Summit district; both auriferous and argentiferous; often carries free gold; with pyrites only, in quartz matrix. San Juan County, has been mined on Red Mountain; argentiferous, with tetrahedrite and galena in quartz veins.

Epidote. Chaffee County, Calumet, fine crystals; Fremont County, occurs near Canon City; Gunnison County, occurs on Italian Mountain.

Erythrite. Gunnison County, Tercelli Mountain.

Ferberite. Boulder County, Nederland, in veins cutting granite, pegmatite, and gneiss; mined. Clear Creek County, small finds reported. Gilpin County, northern part; mined.

Fluorspar (fluorite). Boulder County, mined at Jamestown, and shipped; Chaffee County, at Mount Antero; Clear Creek County, at Georgetown; Custer County, has been mined at Rosita; Dolores County, abundant gangue mineral in Blackhawk mine and prospects of Silver Creek, Rico region; Douglas County, at Devils Head; El Paso County, in quantity at Elk Creek, near Cheyenne and Pikes Peak; mined at Duffields. Gilpin County, in Gregory and Russell districts; Gunnison County, in lead ores near Sherrod; Jefferson County, mined at Evergreen, and shipped; Mineral County, mined at Wagon Wheel Gap; Park County, in northern part of Halls Valley; shipped from Jefferson. San Juan County, in quartz veins in Poughkeepsie Gulch; San Miguel County, in Telluride district; Teller County, Cripple Creek, with gold tellurides.

Freieslebenite. Gunnison County, on Augusta Mountain.

Fuller's earth. Chaffee County, low grade near Salida.

Gadolinite. Douglas County, mined on Devils Head Mountain.

Galena (argentiferous auriferous lead ore). Boulder County, in small quantity in tungsten-bearing veins of Boulder district; Chaffee County, in Alpine, Chalk

Creek, and Cottonwood districts; Clear Creek County, in mines 6 miles southwest of Idaho Springs; carried gold and silver. Dolores County, important ore mineral of Rico district, abundant in Enterprise mine, also Union, Carbonate, and Newman mines; argentiferous. Eagle County, in Red Cliff (Battle Mountain) district. Fremont County, at Cotopaxi. Gilpin County, reported with uranium in Wood, Kirk, and other mines near Central City. Gunnison County, mined at Blistered Horn, Tincup district; Sandy Hook and Gold Links, Gold Brick district, and elsewhere; Elkhorn and Timichi districts, carries gold and silver. Hinsdale County, Galena district, 5 miles west of Lake City. Lake County, important ore at Ohio mine; carries silver and gold; also in silver-lead mines at Leadville. Park County, Horseshoe district, 7 miles west of Garo, on easterly slope of Mosquito Range. Pitkin County, common silver-bearing ore in Aspen district; Mollie Gibson and other mines. Routt County, mined in Slavonia district and at Columbine and near Hahns Peak (Minnie D. and Tom Thumb mines); carries gold. Summit County, in veins of Montezuma district. Teller County, in small quantities in many mines of Cripple Creek district. Occurs in many other mines.

Garnet. Chaffee County, on Ruby Mountain, east side of and across Arkansas River from Nathrop; spessartite variety in rhyolite at Nathrop; large brilliant crystals near Salida; worked intermittently. Fremont County, Grape Creek, 2 miles southwest of Canon City; almandite variety; handsome gems cut; occurs also at Sedalia mine. Gunnison County, grossularite variety on Italian Mountain.

Gas, natural. *See* Natural gas.

Gold (lode). Predominant metal produced in the following districts: Boulder County, Central, Gold Hill, Grand Island, Magnolia, Sugarloaf, and Ward; Chaffee County, Granite, Riverside, and Turret; Clear Creek County, Argentine, Idaho Springs, Lincoln, and Upper Union (Empire); Conejos County, Ute (Platoro), 45 miles southwest of Monte Vista; Dolores County, secondary importance in Lone Cone and Pioneer (Rico) districts; Eagle County, Fulford and Holy Cross; Fremont County, White Horn, 26 miles northeast of Salida; Gilpin County, Central City, Independence, and Pine; Grand County, Grand Lake (Wolverine) and La Platte; Gunnison County, Box Canyon, Cebolla, Cochetopa, Gold Brick, Tincup, and White Earth; Hinsdale County, Park (Sherman); Huerfano County, La Veta; Lake County, Twin Lakes, minor importance at Leadville; La Plata County, California, Needle Mountains (Florida); Montezuma County, East Mancos; Ouray County, Imogene Basin (Camp Bird), Sneefles, Uncompahgre; Park County, Buckskin, Consolidated-Montgomery, Hartsel, Mosquito, Tarryall; Rio Grande County, Decatur, Embargo, Summitville; Routt County, Hahns Peak; Saguache County, Baca Grant (Crespone); San Juan County, Animas (Silverton), Eureka; San Miguel County, Iron Spring (Ophir), Lower San Miguel, Upper San Miguel (Telluride); Summit County, Breckenridge, Frisco, Swan River; Teller County, Cripple Creek, from reduction of tellurides. *See also* Amalgam, Calaverite, and Petzite.

Gold (placer). Produced in the following districts: Chaffee County, Granite; Clear Creek County, Lincoln; Costilla County, Greyback and Plomo; Eagle County, Holy Cross (Eagle River); Jefferson County, Golden; Lake County, Twin Lakes, 9 miles northwest of Granite; Moffat County, Lay (Jackrabbit); Park County, Monquetto and Tarryall; Routt County, Hahns Peak; San Miguel County, Lower and Upper San Miguel (Placerville and Telluride); Summit County, Breckenridge, Swan River. Produced in minor quantity in several other districts.

Grahamite. Grand County, near Granby.

Granite. Chaffee County, quarried at Salida and Turret; Clear Creek County, quarried at Silver Plume; Fremont County, quarried at Cotopaxi and Texas Creek; Gunnison County, fine granite at Aberdeen quarries; State capitol built from it. Jefferson County, quarried at Stone Spur and Buffalo Creek; Larimer County, at Masonville and other points; United States mint at Denver built from Masonville quarry.

Graphite. Chaffee County, good quality amorphous graphite, mined near Turret; originally coal, metamorphosed by igneous intrusion. Gunnison County, occurs 3½ miles north of Pitkin; branches of Quartz Creek; impure; in quartz veins 2½ feet thick. Las Animas County, occurs near Trinidad. This is carbonate from coking coal by igneous intrusion.

Greenockite. Reported with zinc ores at Leadville, Park City, and elsewhere.

Grindstones. Gunnison County, Gunnison.

Gypsum. Custer County, occurs near Arkansas River; Delta County, west side of Grand Canyon of Gunnison River, into Montrose County; Dolores County, as gangue mineral, Rico region, and elsewhere; Eagle County, at Ruedi; worked recently; occurs along Grand and Eagle rivers. El Paso County, has been worked extensively near Perry Park and near Colorado City; Fremont County, Coaldale and Canon City; Jefferson County, opened near Mount Morrison; Larimer County, worked extensively at Arkins near Loveland; thick bed at Owl Canyon and on Sand Creek east of Boxelder, and at several other localities. Montrose County, several places.

Hematite (red iron ore). Gunnison County, prospects near Whitepine and north of Iola Station; Lake County, has been mined at Breece iron mine, Breece Hill, near Leadville; very pure ore; large irregular deposits in porphyry. Pitkin County, very common in mines of Aspen district. Occurs at many other places in State.

Hessite (telluride of silver). Boulder County, Goldhill district, important ore; Eagle County, Redcliff; La Plata County, occasionally important, has been mined; Hinsdale County, Hotchkiss mine.

Hinsdalite. Hinsdale County, Golden Fleece mine, near Lake City.

Hübnerite. Ouray County, Royal Albert vein, Uncompahgre district; mined. San Juan County, several mines near Silverton and Gladstone; has been mined.

Infusorial earth. Denver County, small bed at West Denver; not mined.

Iron. Chaffee County, predominant metal in South Arkansas district. *See also* Brown iron ore, Hematite, Magnetite, Marcasite, Pyrite, Pyrrhotite, and Siderite.

Jet. Las Animas County, Wet Mountain valley, Trinchera Mesa.

Kaolin. Occurs in thousands of mines as gouge, as at Durango Girl mine, on east slope of Lewis Mountain La Plata County. Deposits are known near Silver Cliff, Parkdale, Salida, Newcastle, etc., but quality and extent are not known.

Krennerite. Teller County, Cripple Creek.

Lead. Lead is the predominant metal produced in the following districts: Chaffee County, Alpine, Chalk Creek, Cottonwood; Clear Creek County, Trail, 6 miles southwest of Idaho Springs; Custer County, Spaulding, 14 miles southwest of Florence; Gunnison County, Elk Mountain, Tomichi; Hinsdale County, Galena, 5 miles west of Lake City; Lake County, California (Leadville); Park County, Horseshoe, 7 miles west of Garo; Pitkin County, Columbia, Frying Pan, Roaring Fork (Aspen); Routt County, Slavonia, 40 miles north of Steamboat Springs; Saguache County, Blake (Kerber Creek); Summit County, Montezuma (Snake River). Lead is produced but is less important in many other districts. *See also* Altaite, Anglesite, Cerusite, Cosalite, Galena, Massicot, Minium, and Pyromorphite.

Limestone. Chaffee County, limestone quarried at Garfield and Newett; Boulder and Larimer counties, limestones of Lykins, Morrison, and Niobrara formations burned for lime along foothills of northern Colorado. Douglas County, has been quarried at Silica for lime; El Paso County, Manitou, for lime; Fremont County, quarried at Canon City and Calcite for crushed stone; Jefferson County, quarried at Mount Morrison; La Plata County, at Rockwood; Larimer County, at Ingleside, for sugar refining; Pitkin County, burned for lime at Thomasville; Pueblo County, quarried at Lime near Pueblo. Abundant in many counties.

Limonite. *See* Brown iron ore.

Magnetite (magnetic iron ore). Chaffee County, has been mined in Arkansas Hills, 9 miles from Salida; Costilla County, interbedded with limestone at Grayback Gulch, 5 miles from Placer station; Dolores County, with chalcopyrite in Magnet and Eagle prospects; has been mined for flux. Fremont County, on Iron Mountain near Pine Creek; titaniferous. Gunnison County, prospects on Saguache Mountains and in Cebolla district; Pitkin County, prospects in Elk Mountain divide, 6 miles south of Ashcroft.

Malachite (green copper carbonate). Occurs in hundreds of places, among them: Fremont County, mined at Sedalia mine; Montrose County, in ores of Cashin mine, La Sal Creek; Routt County, prospects on Hahns Peak; San Juan County, in Bear Creek district.

Manganese. Eagle County, considerable manganiferous silver ore mined at Iron Mask mines, Gilman; Lake County, large output from lead-silver mines of Leadville district. *See also* Alabandite, Psilomelane, Pyrolusite, and Rhodochrosite.

Marble. Boulder County, small deposits; Chaffee County, near Salida, Calumet, Monarch, and Mayville; Gunnison County, quarried at Marble and along Yule Creek; Larimer County, small beds west of Fort Collins; Pitkin County, quarried at Crystal City; also in other localities.

Marcasite. Occurs in hundreds of mines, as in Routt County, in veins of Hahns Peak district; San Juan County, in ore bodies in Bear Creek district.

Massicot (oxide of lead). Occurs in many mines. Dolores County, with galena ores near Rico; argentiferous; Lake County, at Leadville, and elsewhere. San Miguel County, with galena in upper San Miguel region; argentiferous.

Melaconite. Pitkin County, thin coatings in Aspen district mines.

Mimetite. Chaffee County, Monarch and Garfield district.

Minium. Lake County, Leadville; Pitkin County, in oxidized ores of Aspen district, and at other places; San Miguel County, Telluride.

Molybdenite (sulphide of molybdenum). Chaffee County, small quantities near Buena Vista and other places. Gunnison County, 2 miles from Pitkin in quartz veins; possible source of molybdenum. Lake and Summit counties, Fremont Pass; promising. San Juan County, near Silverton. Teller County, in Cripple Creek district; occurs also at many other places.

Monazite. Chaffee County, in black sands at Buena Vista; Costilla County, in San Luis Valley; Routt County, at Timber Lake.

Mica (muscovite). Clear Creek County, reported from Idaho Springs; Fremont County, mined near Cañon City and at Micanite; Jefferson County, at Morrison; Larimer County, on Buckhorn Creek; Mesa County, has been mined 8 miles south of Grand Junction.

Natural gas. Boulder County, considerable quantity produced from Boulder field; Costilla County, near Mosca and other places in San Luis Valley; Delta County, occurs in oil shales of Green River formation on head of Muddy Fork; Fremont County, considerable quantity produced from Florence field; Pitkin County, "blowers" in middle Cretaceous shales at Coal Basin; undeveloped; natural flow limited. Pueblo County, Nepesta.

Niccolite. Custer County, small quantity at Silver Cliff; Fremont County, occurs at Gem mine, Grape Creek Canyon; in dolomite, with bornite, and rarely with native silver.

Nicholsonite. New zinc mineral found in some quantity at Leadville.

Opal. Opal of inferior quality is found at several places: Buffalo Peaks, Cripple Creek, Idaho Springs, Ute Creek.

Petroleum. Boulder County, Boulder oil field, 3 miles northeast of Boulder; high-grade light illuminating oil. Fremont County, south of Florence, field 10-20 square miles. Mesa County, small wells near De Beque. Routt County, Yampa field; used as lubricant. Rio Blanco County, Rangely oil district. Petroleum has been found also in Archuleta, Pueblo, and Moffat counties.

Petroleum (oil shales). Delta and Garfield counties, extensively developed, geologically, constituting the greater part of the rocks of the Green River formation (Eocene). In the Book Cliffs, the richer rock occurs in bands, about 50 in number, from 2 to 15 feet thick. Destructive distillation gives from 15 to 35 per cent of condensed hydrocarbons, and 10 to 20 per cent of gas. Prospective source of lubricating oil.

Petzite (telluride of gold and silver). Found in many mines in Colorado in Boulder, Clear Creek, Gunnison, and Hinsdale counties. San Juan County, most valuable ore in Gold Bug and other mines in Bear Creek district.

Phenacite. Chaffee County, occurs at Mount Antero. El Paso County, occurs in Crystal Park, 2 miles southwest of Manitou; has been mined at Pikes Peak; gem stone. Teller County, near Florissant.

Pitchblende. Clear Creek County, Jo Reynolds mine. Gilpin County, mined in Kirk, Wood, German, Calhoun, and Belcher mines, near Central City; reported in small quantity in other places.

Platinum. Chaffee County, occurs in black sands of Buena Vista; Clear Creek County, Centennial mine, Georgetown; Pitkin County, Aspen; Saguache County, Liberty; San Miguel County, Telluride, in small quantities.

Polybasite. Clear Creek County, mines at Georgetown and Silver Plume. Dolores County, considerable quantity at Newman Hill mine, Rico region. Ouray County, Yankee Girl mine; Pitkin County, in Molly Gibson and Smuggler mines, Aspen district; San Juan and San Miguel counties, occurs in Red Mountain district. San Miguel County, Marshall basin; occurs in quartz veins with pyrargyrite, sphalerite, and stephanite; not uncommon in Mendota mine.

Proustite (ruby silver, light). Dolores County, Newman Hill mine, Rico district; Gunnison County, small quantity with arsenopyrite in Ruby district; Ouray County, at Yankee Girl mine; Routt County, in veins of Hahns Peak district; San Miguel County, at Sheridan mine; occurs also in many other Colorado mines.

Psilomelane. Chaffee County, small quantity near Garfield; Custer County, occurs south of Round Mountain, at Silvercliff.

Pyrargyrite (ruby silver, dark). Clear Creek County, in Georgetown mining district; Dolores County, reported from Newman Hill mine; Gilpin County, rare near Central City; Gunnison County, in Ruby district; Hinsdale County, near Lake City; Ouray County, in Sneffle's district; Routt County, in Hahns Peak region; San Miguel County, in Marshall Creek basin; Summit County, in Montezuma mining district.

Pyrite. Pyrite is found in nearly every county along the Rocky Mountains: Boulder County, in Ward district; Clear Creek County, in Georgetown mining district; gold-silver ore. Dolores County, important ore of Rico district; carries small quantities of gold and silver; mined at Enterprise, Union, Carbonate, and other mines. Fremont County, mined at Sedalia mine for gold. Gilpin County, abundant; important gold ore. Gunnison County, in quartz at Sandy Hook and Gold Links mines; carries gold. Hinsdale County, near Lake City. Lake County, mined at silver-lead mines, Leadville. La Plata County, Neglected mine, 15 miles from Durango. Larimer County, at Pearl. Ouray County, in mines along Uncompahgre River, between mouth of Dexter Creek and Ouray; contains gold and silver; common in other places. Pitkin County, original sulphide of Aspen district ore bodies; mined for silver. Rio Grande County, in Summit district. Routt County, common vein mineral of claim on Farwell Mountain, Hahns Peak region. San Juan County, Silverton district; mined at Ohio mine; common at many mines. San Miguel County, common.

Pyrolusite (black oxide of manganese). Gunnison County, occurs in Steuben Valley, 6 miles southwest of Gunnison, and in Cebolla Valley; Hinsdale County, occurs near Lake City.

Pyromorphite. Lake County, occasionally in oxidized ores of Leadville district, silver-lead mines.

Pyrrhotite (magnetic iron pyrites). Chaffee County, Monarch and Garfield area; Jefferson County, Malachite mine, and many other places; San Juan County, has been mined in Needle Mountains in limited quantity; auriferous.

Quartz. Jefferson County, mined from veins in foothills near Golden, and used in manufacture of fire bricks at Golden.

Quartz (moss agate, silicified wood, and smoky quartz). Very common and much used in the manufacture of jewelry, ornaments, etc. Smoky quartz occurs near Pikes Peak, and is known in trade as "smoky topaz" or "cairngorm stone."

Quartz (rose). Fremont County, 6 miles north of Texas Creek; some mined as gems. Jefferson County, Floyd Hill, Bear Creek, etc. Larimer County, large body in granite 25 miles west of Fort Collins; cut as gem stone.

Quicksilver. Boulder County, occurs in Magnolia district. La Plata County, Ruby claim south of Cumberland Peak. *See also* Amalgam and Cinnabar.

Rhodochrosite. Boulder County, Ward district; Dolores County, gangue mineral of Newman Hill and Enterprise mines, Rico region; Lake County, Alicante; Summit County, Peru district.

Roscoelite. Boulder County, sparingly in gold veins; Rio Blanco County, reported to occur along Coal Creek, near Meeker; San Miguel County, large deposits at Newmire and Placerville.

Rutile. El Paso County, occurs near St. Peters Dome, Pikes Peak district.

Sand (building). Dug at many places; Denver County, Denver; Fremont County, Canon City; La Plata County, Animas City and Durango; Pueblo County, Pueblo; Rio Grande County, Monte Vista.

Sand (molding). Dug at Denver and Pueblo.

Sandstone. Sandstone is quarried at Boulder County, Boulder and Lyons; Delta County, Montrose; Douglas County, Castle Rock; El Paso County, Colorado City; Fremont County, Canon City; La Plata County, Durango; Larimer County, Arkins, Stout, and other places; Pueblo County, Pueblo; Rio Grande County, Del Norte; Routt County, Steamboat Springs.

Sandstone (asphaltic). Grand County, Upper Willow Creek, sec. 24, T. 4 N., R. 77 W.

Scheelite. Boulder County, small quantities occur with ferberite in the Boulder district; Lake County, Golden Queen mine; San Juan County, near Silverton and Gladstone with hübnerite.

Serpentine. Gunnison County, occurs near Gothic; Park County, occurs in Buckskin Gulch, a mottled rock, largely calcite, but deeply colored by true serpentine; prospective use as ornamental stone.

Siderite. Gunnison County, occurs with magnetite and hematite in Cebolla Valley, near Powderhorn. Jefferson County, occurs near Bear Creek; zinciferous. Pitkin County, occurs in iron ore near Ashcroft, Taylor Peak district.

Silver. Predominant metal produced in the following districts: Chaffee County, La Plata, Monarch-Garfield; Clear Creek County, Georgetown, Jackson, Montana; Custer County, Hardscrabble (Rosita, Silver Cliff); Dolores County, Lone Cone and Pioneer (Rico); Eagle County, Battle Mountain (Red Cliff); Gunnison

County, Quartz Creek, Rock Creek, Ruby; Hinsdale County, Lake (San Cristobal); Mineral County, Sunnyside (Creede); Park County, Halls Gulch and Sacramento; Pitkin County, Lincoln; Saguache County, Crystal Hill; San Miguel County, Mount Wilson; Summit County, Peru, Tenmile (Kokomo). Silver is of minor importance in many other districts. *See also* Acanthite, Amalgam, Calaverite, Cerargyrite, Embolite, Hessite, Petzite, Polybasite, Proustite, Pyrargyrite, Stephanite, Stromeyerite, and Sylvanite.

Silver (native). Boulder County, occurs in Caribou mine and Up-to-Date property, and mines of Ward district, especially the White Raven; Clear Creek County, small quantity of wire silver found in Georgetown district; Dolores County, reported from Enterprise and Puzzle mines; Gunnison County, occurs in Ruby district and near Gothic; Hinsdale County, in Galena district; Lake County, occasionally found in silver-lead mines at Leadville. La Plata County, occurs along Bear Creek, usually with galena, tetrahedrite, and stephanite; Montrose County, Cashin mine, La Sal Creek; Pitkin County, irregular wires and masses of silver in Molly Gibson and Smuggler mines, Aspen district; Teller County, in small quantities in many mines of Cripple Creek district.

Smaltite (gray cobalt ore). Gunnison County, occurs near Gothic in calcite gangue, associated with small quantities of erythrite and native silver.

Sphalerite (zinc blende). Chaffee County, Monarch and Garfield area; Clear Creek County, Georgetown and Silver Plume mines, Idaho Springs district; carries silver. Dolores County, with galena and chalcopyrite in Rico district; abundant in Newman Hill silver ores and Sambo mines; mined for zinc alone in Atlantic Cable mine. Fremont County, Sedalia mine; Gilpin County, a common mineral usually argentiferous, sometimes highly so, and occurring associated with pyrite, chalcopyrite, galena, and tetrahedrite; has been mined for silver. Gunnison County, Blistered Horn, Tincup district; Sandy Rock and Gold Links, Gold Brick district, and other mines; carries gold and silver. Hinsdale, La Plata, Ouray, and San Miguel counties, a very common, usually argentiferous mineral; common associate, galena; frequently with chalcopyrite, tetrahedrite, or pyrargyrite. Jefferson County, Malachite mine. Lake County, silver-lead mines at Leadville. San Juan County, in ores of Ohio mine near Whitecross; mined for gold and silver; also mined at other places. Found also in other mining counties.

Spinel. Fremont County, occurs at Sedalia mine.

Stephanite (brittle silver). Clear Creek County, frequently associated with other silver-bearing minerals; Dolores County, reported from Newman Hill mine, Rico region; Gunnison County, mined at Red Jacket; Hinsdale County, limited quantity in Galena district; Ouray County, occasionally found in Sneffle and Uncompahgre districts; Summit County, occurs in Montezuma mining district. Mined also at other places.

Stibnite (antimony sulphide). Not known in commercially valuable deposits, though small quantities are found in many mining districts, as Boulder County, in several mines; Clear Creek County, Alice mine; Grand County, Lost Lakes; San Juan County, North Star mine; Teller County, in Cripple Creek district.

Stromeyerite (copper and silver sulphide). Boulder County, Grand Lode. Clear Creek County, occurs with bornite, tetrahedrite, etc., at Plutus mine, Idaho Springs; occasional. Ouray County, in quantity in Yankee Girl mine; has been mined.

Sulphur. Gunnison County, has been mined at Vulcan. Mineral County, occurs 25 to 30 miles southwest of Creede. Several other deposits are reported.

Sylvanite. Boulder County, associated with tungsten ore at mines in Boulder district. La Plata County, occurs at Durango Girl mine on east slope of Lewis

Mountain. Teller County, important gold ore of Cripple Creek district. Occurs also at other places.

Tennantite. Much of the so-called tetrahedrite of the sulphide ores of Colorado is tennantite. Clear Creek County, occurs in silver-bearing ores at Georgetown and at Silver Plume mines. Gilpin County, in large number of mines. Pitkin County, very common in Aspen district, Molly Gibson, and other mines. Also in mines of Ouray, Hinsdale, and San Juan counties.

Tetradymite (bismuth telluride). Boulder County, Red Cloud mine. Fremont County, occurs near Whitehorn.

Tetrahedrite (gray copper ore). Clear Creek County, mined for silver in Georgetown and Silver Plume mines. Dolores County, silver-bearing in Rico district, Enterprise, and Rico-Aspen mines. Gilpin County, reported with uranium in Wood, Kirk, and other mines near Central City. Gunnison County reported from Ruby district. Hinsdale County, has been mined near Lake City. Ouray and San Miguel counties, very abundant in silver ores. Pitkin County, very common in Aspen district, Molly Gibson, and other mines. San Juan County, important ore of Ohio mine, near Whitecross; mined for silver; Bear Creek district, Gold Bug, and other mines; gold and silver bearing. Teller County, mined in Cripple Creek district.

Topaz. Chaffee County, Mount Antero and Ruby Mountain; on east side of Arkansas River, near Nathrop. El Paso County, Crystal Park, 2 miles southwest of Manitou Springs. Teller County, occurs at Pikes Peak, and mined intermittently at Crystal Peak, 4 miles north of Florissant.

Tourmaline. Fremont County, 2 miles north of Royal Gorge and 5 miles northwest of Canon City; opaque but colored. Gilpin County, near Blackhawk; Larimer County, Estes Park; Teller County, Rhyolite Mountain.

Trona. Deposits estimated at 100,000 tons or more exist in the soda lakes of the San Luis Valley; a little development has been done.

Tungsten. *See* Ferberite, Hübnerite, and Scheelite.

Turquoise. Conejos County, 13 miles east of La Jara; Eagle County, Mount of Holy Cross; Mineral County, Last Chance mine, Creede; Saguache County, near Villa Grove.

Uranium minerals. *See* Carnotite and Pitchblende.

Vanadium. Found in many localities as carnotite, roscoelite, calciovolborthite, and possibly volborthite (which see). Custer County, 7 or 8 miles southeast of Silver Cliff, reported to occur as in Huerfano County. Eagle County, with silver ores in sandstone on Brush Creek, form of mineral unknown. Huerfano County, in an unidentified mineral near head of Pass Creek, south of Malachite. Montrose County, found in the Paradox Valley country as calcium vanadate; possibly two forms; unnamed, awaiting future investigation.

Volborthite. Huerfano County, near head of Pass Creek, south of Malachite. The mineral has not been definitely identified, but is probably either volborthite or calciovolborthite, or both. La Plata County, Boren Gulch, vanadium occurs in a quartz vein in a mineral which is probably volborthite or calciovolborthite, and probably also in an amorphous yellowish-green mineral. Park County, reported from Garo.

Volcanic ash. Exists in enormous quantity in several of the eastern counties; in Huerfano County, near Cripple Creek and Durango; Yuma County, has been shipped from Wray for scouring powder.

Wolftonite. Lake County, a new zinc mineral found in considerable quantities in Leadville; it is a magnetic oxide of zinc and manganese with trace of iron.

Wood (opalized). El Paso County, has been obtained in eastern part of county with jasperized wood; Bijou Basin. Silicified wood is very common.

Zinc. Fremont County, predominant metal in Currant Creek (Micanite) district. *See also* Sphalerite.

CONNECTICUT.

Agate. Hartford County, at Farmington; New Haven County, at East Haven; Litchfield County, at Woodbury; has been cut for seal stones. In various localities in amygdules in the trap.

Amethyst. Occurs occasionally in amygdules in trap at Meriden.

Aquamarine. Middlesex County, some of gem quality has been found in Portland and Haddam.

Arsenopyrite (arsenical pyrite). Fairfield County, in lead mine in Wilton and at Lanes mine, Monroe; Middlesex County, in small quantities at the old Cobalt-Nickel mine, in Chatham; New Haven County, in mine at Derby, and in Oxford and Bethany.

Asbestos (actinolite). Litchfield County, at New Hartford and Barkhamsted.

Azurite (blue carbonate of copper). Hartford County, in small quantities at Rocky Hill near Hartford; also at other copper deposits.

Barite. New Haven County, in Triassic sandstone in Cheshire, and in small quantities elsewhere. The Cheshire barite was formerly mined to mix with white-lead paint.

Beryl. Fairfield County, at Branchville; Litchfield County, at New Milford; Middlesex County, at several quarries in Middletown, Portland, Chatham, and Haddam; abundant in many of the pegmatite dikes; some aquamarine of gem quality has been found in Portland and Haddam; New Haven County, moderately abundant in Southford quarry.

Bismuth (native). Fairfield County, small quantities associated with arsenopyrite, pyrite, wolframite, etc., in quartz vein at Monroe.

Bismuthinite. Middlesex County, with chrysoberyl in minute quantities at Haddam, and sparingly at a small feldspar quarry formerly worked in Portland.

Bornite (variegated copper). Hartford County, at Bristol copper mine, Bristol; Litchfield County, with chalcocite and malachite at Wolcottville, and elsewhere; occurs in quartz veinlets in Rocky Hill, quarry at Winsted; New Haven County, occurs with diabase at Mount Carmel, Hamden.

Brown iron ore (bog iron ore, limonite). Litchfield County, mined at Davis and Orehill mines, near Lakeville; large deposits at Sharon and Salisbury; has been mined; New London County, occurs at Colchester; Tolland County, bog iron mined and smelted in Stafford and Hebron townships; Windham County, at Woodstock.

Calamine (silicate of zinc). Fairfield County, with galena at Brookfield.

Cassiterite (tin ore). Middlesex County, few crystals found at Haddam.

Cement material. Outcrops of suitable limestone are small and few.

Cerussite (lead carbonate). Fairfield County, on galena at Brookfield.

Chalcocite (copper glance). Hartford County, was mined in very small quantity at Simsbury mine, Granby; splendid crystals formerly obtained in Bristol mine at Bristol; Tallwaa mine, Hampden; Litchfield County, with bornite and malachite, Wolcottville; New Haven County, occurs in southeastern part of Cheshire and in Hamden.

Chalcopyrite (copper pyrite). Fairfield County, in various places in Trumbull; Hartford County, in granite gneiss, Bristol; Litchfield County, with pyrrhotite at Mine Hill; Middlesex County, in Middletown lead mine; New Haven County, near Lamberts mine, Orange, and in small quantities at other places.

Chrysoberyl. Middlesex County, crystals at Haddam, little of gem quality. Locality has been inaccessible in recent years.

Clay (brick). Occurs abundantly; has been used in following districts: Berlin, Clayton, Cromwell, Elmwood, Hartford, Kensington, Middletown, Milldale, New Haven, Parkville, Quinnipiac, South Windsor, Thompsonville, and Windsor.

Clay (fire). Litchfield County, has been dug 2 miles south-southwest of Boardmans Bridge.

Clay (kaolin, porcelain). Fairfield County, has been found at Sherman; Hartford County, at Granby; Litchfield County, dug at West Cornwall and shipped to potteries outside of State; occurs also at New Milford and Kent.

Columbite. Hartford County, with feldspar, near Glastonbury; found in several feldspar quarries in Middletown, Portland, and Haddam. A large quantity found some years ago at one quarry in Portland no longer worked.

Copper (native). Hartford County, small quantities at Farmington; New Haven County, occasionally found in Triassic sandstone or trap, Hamden.

Copper minerals. *See* Azurite, Bornite, Chalcocite, Chalcopyrite, Cuprite, and Malachite.

Cordierite. Middlesex County, has been found at Haddam Neck.

Corundum. Litchfield County, found near Barkhamsted; with talc and pyrite at Litchfield; London County, sparingly, with sillimanite near Norwich; not mined.

Cuprite. Hartford County, Simsbury mine, Granby, very small quantity.

Diabase. *See* Trap rock.

Dolomite. *See* Marble.

Feldspar (orthoclase or microcline). Fairfield County, occurs at Branchville, ground and shipped out of State for manufacture of porcelain; Hartford County, Howe quarry, 2 miles south of South Glastonbury; numerous quarries, large and small, worked for longer or shorter times, in the pegmatites of Middletown, Portland, Haddam, and Chatham; New Haven County, mined near Southford.

Flagstone. Fairfield County, near Bridgeport; Hartford County, red sandstone, quarried at Enfield; Litchfield County, at Roxbury; Middlesex County, gneiss quarries on Connecticut River, at Middletown, Chatham, and Haddam; New London County, large flags quarried in Lebanon; Tolland County, mica schist of Bolton Mountain, extensively quarried; Windham County, micaceous quartzite quarried at Killingly.

Fluorspar (fluorite). Farifield County, in topaz vein in Trumbull, used for flux; Litchfield County, at Plymouth; Middlesex County, Haddam Neck, and at the old lead-silver mine, Middletown; Windham County, in gneiss at Willimantic. Nowhere in considerable quantity, except at Trumbull.

Galena. Fairfield County, in limestone at Brookfield, in quartz veins at Monroe; Hartford County, at Chatham; Middlesex County, with sphalerite, chalcopyrite, and pyrite at Middletown; and several other localities. Was mined for lead in Colonial and Revolutionary times; for a few years, about 1860, mined for silver.

Garnet. Hartford County, quarry near South Glastonbury; Litchfield County, was mined at Roxbury as abrasive; Middlesex County, small garnets in pegmatite at Andrews' quarry, Portland, and in Eureka quarry; New Haven County, in Southford quarry. In larger or smaller quantities at most of the pegmatite (feldspar) quarries.

Gneiss. Quarried for foundation stone at many places. Hartford County, Glastonbury; Middlesex County, at Haddam, quarried for curbstone; New London County, at quarries on Thames River above New London; Tolland County, at Union; Windham County, at Plainfield, Willimantic, and Putnam.

Granite (building, structural). Quarried at Branford, Bristol, Greenwich, Groton, Guilford, Lyme, Middletown, Norfolk, Roxbury, Stonington, and Torrington. Much of the granite quarried is a granite gneiss.

Granite (curbing and trimming). Quarried at Ansonia, Bolton, Bridgeport, Cornwall, East Litchfield, Glastonbury, Norwalk, Roxbury, Seymour, Sterling, Torrington, Waterford, and Willimantic.

Granite (inscriptional, monumental). At Center Groton, East Lyme, Groton, Lyme, Stonington, Thomaston, and Waterford.

Granite (paving). At Guilford and Sterling.

Granite (riprap). At Sachem Head, Guilford; Mason Island, Stonington.

Granite (road material). At Bridgeport Jail; Danbury; Torrington; Town Hill.

Graphite. Fairfield County, at Danbury and Redding; Litchfield County, found in western part of Cornwall; New Haven County, in northern part of Bethany; Windham County, has been quarried in northwest corner of Ashford.

Grindstone. Hartford County, fine-grained quartzose mica slate was quarried in Marlborough; not now produced.

Iron minerals. *See* Brown iron ore, Magnetite, Pyrrhotite, and Siderite.

Lead minerals. *See* Cerussite, Galena, and Pyromorphite.

Lepidolite. Middlesex County, fine granular masses in pegmatite at Haddam and Middletown; larger plates or crystals in pegmatite at Portland and Haddam.

Limestone (crushed stone). Litchfield County, quarried at Canaan.

Limestone (flux). Litchfield County, was quarried at East Canaan.

Limestone (hydraulic). Hartford County, near Berlin in Southington; in thin strata, compact, earthy, and somewhat bituminous; Northford, a gray limestone.

Limestone (lime). Fairfield County, magnesian limestone burned near Redding, Brookfield, Ridgefield, and Danbury; Litchfield County, at Canaan.

Limonite. *See* Brown iron ore.

Magnetite (magnetic iron ore). Fairfield County, was mined and smelted in small quantities at New Preston and at Redding; Litchfield County, in Sharon Township; Middlesex County, near Haddam; New Haven County, northwest of Madison; Winchester County, in northwest corner.

Malachite (green carbonate of copper). Hartford County, principal ore at Simsbury mine, Granby, but not abundant. Disseminated through sandstone.

Marble. Litchfield County, old quarries in East Canaan and Marbledale. Dolomite: Litchfield County, abundant; was quarried at New Preston.

Mica (muscovite). Found in large plates at Middletown, Portland, Haddam, and elsewhere in pegmatites; the large plates are too irregular and too much flawed to use as isinglass. Recently it has been torn into shreds for an insulating material. Muscovite sometimes associated with biotite or lepidolite in the same crystal. Also found in the topaz veins at Trumbull.

Mineral paint. Fairfield County, soapstone ground at Greenwich; asbestos rock at Stamford, talcose slate at Wilton; Litchfield County, soapstone ground at Barkhamsted.

Molybdenite (sulphide of molybdenum). Hartford County, in pegmatite at South Glastonbury; Middlesex County, in gneiss quarries at Haddam.

Monazite. Middlesex County, crystals in pegmatite at Andrews's quarry, Portland (no longer worked). New London County, in small crystals with sillimanite at Norwich. Nowhere in commercial quantities.

Pitchblende. *See* Uraninite.

Pyrite. Fairfield County, at Newtown; Hartford County, in slate at Windsor; Litchfield County, at Winchester; New Haven County, near North Madison. Small quantities in other localities; not now produced.

Pyromorphite (green lead ore). Fairfield County, with galena at Brookfield.

Pyrrhotite. Fairfield County, small quantity mined at New Fairfield; Litchfield County, occurs with chalcopyrite and pyrite at Prospect Hill, Bradleyville. Middlesex County, in small quantities in pegmatite at Portland and elsewhere.

Quartz. Litchfield County, at Long Hill and Lantern Hill, North Stonington; New London County, 2 miles east of Roxbury station, and 3 miles north of Litchfield; New Haven County, quarried near Southford. The pegmatites of Portland and other places are worked chiefly for feldspar, but the quartz is also ground and used for various purposes. Rose quartz has been found in pegmatite at Portland and Chatham.

Road metal. *See* Granite, Limestone, and Trap rock.

Rutile. Fairfield County, at North Greenwich; has been mined in small quantities at Monroe; Hartford County, at Granby; Litchfield County, at Plymouth.

Sand (building). Hartford County, at Plainville, New Britain, and Windsor Locks. Dug in small quantity at other places.

Sand (molding). Hartford County, New Britain, and Windsor Locks.

Sandstone. Varies from nearly white to brick red and dull brown; Hartford County, at Buckland; Middlesex County, at Portland; New Haven County, at East Haven; and at other localities in the Triassic area. This area extends along both sides of the Connecticut River from northern boundary of State to Middletown; thence it extends southwestward to New Haven.

Sapphire (asteriated). Litchfield County, at Litchfield.

Scheelite (tungsten ore). Fairfield County, has been mined at Trumbull.

Serpentine. New Haven County, has been quarried at Milford.

Siderite (spathic iron ore). Litchfield County, has been mined at Mine Hill, Roxbury.

Slate. Tolland County, quarried in Stafford for local use.

Sphalerite (zinc blende). Fairfield County, Lane's mine, Monroe, and at Brookfield; Middlesex County, Middletown lead mine; in small quantity in pegmatite at Portland and elsewhere.

Spodumene. In pegmatite at Branchville. Crystals often very large; sometimes altered to cymatolite. Associated with numerous rare minerals.

Tin. *See* Cassiterite.

Topaz. Fairfield County, found at Trumbull; Windham County, at Willimantic.

Tourmaline. Fairfield County, occurs at Monroe; Middlesex County, mined with feldspar at Strickland's quarry, Portland; green. Some of it is of gem quality. Mined at Haddam Neck quarry, Haddam; small gems cut; considerable gem material obtained; quarry no longer worked. New Haven County, intergrown with quartz at Southford quarry; black. Black tourmaline found in nearly all the pegmatite quarries.

Trap rock. Fairfield County, quarried at Bridgeport; Hartford County, near Newington, Rocky Hill, and Plainville; Middlesex County, Middlefield, New Haven County, Branford, East Haven, Meriden, Milford, New Haven, and Westville.

Tremolite. Litchfield County, in dolomite at Canaan.

Uraninite (pitchblende). Fairfield County, at Branchville; Middlesex County, at Andrews's quarry and Strickland's quarry, Portland; Windham County, at Willimantic. At the two quarries in Portland it occurs in amorphous grains, and in octahedral crystals, some more than one-half inch in diameter. Occurs nowhere in commercial quantities; only as mineralogic specimens.

Whetstone. Tolland County, mica schist formerly quarried at Bolton and Vernon; Windham County, at Woodstock.

Wolframite (tungstate of iron). Fairfield County, at Lane's mine, Monroe, and in topaz-quartz vein at Trumbull.

DELAWARE.

Asbestos. Newcastle County, in serpentine at feldspar quarries northeast of Wilmington; no production.

Brown iron ore (brown hematite, bog iron ore, limonite). Kent County, at East Dover; Newcastle County, Iron Hill, and Chestnut Hill near Newark, has been mined; Sussex County, Little Creek, 2 miles south of Laurel; near Georgetown; Collins's ore bed on Green Meadow Branch of Deep Creek; Green Branch, 10 miles west of Millsboro; Burtons Branch, 1 mile west of Burton.

Cement material (Portland). Limestone suitable for cement occurs in extreme north part of State, but outcrops are small. Greensand marl may be used.

Clay (brick). Dug at the following places: Kent County, near Dover, Houston, Smyrna, and Wyoming; Newcastle County, at Blackbird, Elsmere Junction, Newark, and elsewhere; Sussex County, Blades, Bridgeville, Dagsboro, and elsewhere.

Clay (fire). Newcastle County, Newcastle, dug and shipped, used for fire pots and crucibles.

Clay (kaolin). Newcastle County, dug at Hockessin and 4 miles north of Newark.

Clay (pottery). Newcastle County, was dug at Christiana.

Corundum. Newcastle County, small quantity near Chandlers Hollow.

Cyanite. Delaware County, Darky Creek.

Feldspar. Newcastle County, Tucker's quarry near Wilmington; Tweed's quarry, 2½ miles north of Newark near Pleasant Hill; and Hockessin pits.

Gneiss. Quarried in northern part of State.

Granite. Gneiss and granite are quarried for ballast, building, curbing, concrete, road making, rubble, riprap, at many places in northern part of State.

Infusorial earth. Somewhat impure; abundant in Calvert formation; not used; outcrops on southern tributaries of Appoquinimink Creek and valley of Hangmans Run.

Kaolin. *See* Clay.

Limestone. Newcastle County, has been quarried at Jeane's, on Pike Creek; Klair's, 2 miles west of Centerville; Bullock's, on Brandywine, near Pennsylvania line.

Limonite. *See* Brown iron ore.

Marble. Newcastle County, small exposures.

Marl (greensand). Newcastle County, dug at many localities; occurs in Cretaceous deposits at St. Georges Hundred, St. Georges; Middletown, 3 miles west, on Bohemia Creek, at head of tidewater; Cantrell's bridge, north side of Appoquinimink; Silver Run; Dwyers Run; Noxentown Branch of Appoquinimink; Port Penn; Latman's mill on branch of Dwyers Creek; Scotts Run.

Ocher. Sussex County, with limonite.

Quartz. Newcastle County, white granular quartz has been quarried 2½ miles north of Newark and ground at Tweed's mill, near Newark.

Road metal. Gravel is abundant in many localities. *See also* Gneiss, Granite, and Trap rock.

Serpentine. Newcastle County, occurs 6 miles northwest of Wilmington.

Sand (building). Unlimited quantity of good quality at many places.

Sand (glass). Newcastle County, dug at Christiana.

Sand (molding). Newcastle County, dug at Christiana.

Trap rock. Newcastle County, quarried at Wilmington.

DISTRICT OF COLUMBIA.

Clay (brick). Occurs in extreme eastern and southern portion of Washington and at intersection of Bladensburg Road and Florida Avenue, in Potomac and Columbia formations. Washington is supplied by large brickyards on west side of Potomac River in Virginia.

Clay (terra cotta). Worked extensively for terra-cotta tile at Lamond, Terra Cotta, and University station, on Metropolitan Branch of Baltimore & Ohio Railroad. Many large masses east of Anacostia River.

Diorite. Has been quarried near Georgetown but is so tough and difficult to work that little is used; was quarried at east end of Connecticut Avenue Bridge for concrete used in bridge.

Granite. Has been quarried on Broad Branch of Rock Creek.

Gneiss. Granite gneiss has been quarried at east end of Chain Bridge and at the receiving reservoir near Chain Bridge.

Quartz. Vein quartz abundant in northwestern part of District; has been crushed for concrete and road material.

Road metal. Granite, diorite, and granite gneiss are abundant and have been crushed for road material. *See also* Sand and gravel, and Quartz.

Sand (building). Principal supply dredged from Potomac River. Deposits of Potomac formation have been worked at number of places in Washington and vicinity. Old pit one-half mile south of Anacostia; new pit at Benning. Sand under clay at Terra Cotta is used for tempering clay. Dug near Lamond and made into sand-lime brick.

Sand and gravel. For road material and concrete; have been dug at many localities and dredged from Potomac River. Gravel dug at Benning is shipped for Maryland roads.

FLORIDA.

Brown iron ore. *See* Limonite.

Cement material. Limestone suitable for cement covers large part of northern Florida; not utilized.

Clay (brick). Dug at Alachua County, Campville; Clay County, Black Creek, B. P. Landing, and Green Cove Springs; Columbia County, Lake City; Duval County, Jacksonville and St. Nicholas; Escambia County, Brent Station, Dolores, Quintette, and elsewhere; Gadsden County, Lawrence; Hillsboro County, Tampa; Holmes County, Eleanor; Lake County, Sorrento and Whitney; Leon County, Tallahassee; Nassau County, Callahan; Walton County, Glendale; Washington County, near Chipley. Occurs but not used in Hamilton County, near Marion, and on Suwannee River at White Springs; Leon County, 18 miles southwest of Tallahassee.

Clay (fire). Escambia County, dug at Brent Station.

Clay (pottery). Lake County, dug at Yalaha, Okahumpka, and Richmond; Putnam County, at Edgar, Johnson, and McMeekin.

Coquina (limestone). Brevard County, St. Augustine quarries, Rock Ledge on Indian River; used for building stone. St. John County, Anastasia Islands and other points near ocean; used as building stone and road metal.

Fuller's earth. Gadsden County, dug at Jaimeson and Quincy, large deposits; Manatee County, at Ellenton. Occurs in following places but is not mined: Alachua County, Gainesville; Columbia County, High Falls, 8 miles southeast of Lake City; Leon County, 13 miles west of Tallahassee, sec. 26, T. 1 N., R. 3 W.; Liberty County, Rock Bluff and along headwaters of Rock and Sweetwater creeks; 27,658 tons produced in 1911.

Gypsum. Sumter County, 6 miles west of Panasoffkee with limestone. Not used.

Infusorial earth. Lake County, near Eustis, mined to some extent.

Lignite (brown coal). On Suwannee River; has been mined.

Limestone. Alachua County, has been quarried at Gainesville; Dade County, Miami oolite quarried at Miami for serveral large buildings, and used also as road metal; De Soto County, occurs at Charlotte Harbor; Hillsboro County, Fort Brooke; Jackson County, from Campbellton to Marianna; Manatee County, Manatee River; Marion County, Kendrick, Ocala, and Silver Springs; Monroe County, oolite at Key West; Orange County, Rock Spring; Wakulla County, St. Marks. Occurs also in Hernando, Holmes, Leon, Walton, and Washington counties.

Limestone (lime). Marion County, burned at Ocala and Kendrick.

Limonite (bog iron ore). Duval County, found around Beauclerc; Volusia County, 12 miles east of Seville, and at several points on the Florida East Coast Railway.

Malachite (green carbonate of copper). Suwannee County, reported 5 miles southeast of Dowling Park.

Marl. Occurs very generally skirting the eastern and southern edges of the limestone ridge traversing the axis of the State. Isolated deposits have been noted at Jacksonville and on Fort George Islands, Duval County. The marl is used locally on many orange groves on the St. Johns River, particularly at Sanford, Orange Bend, and Lanier.

Mineral paint. Lee County, Estero Bay, not developed.

Peat. Extensive deposits throughout the State. "Machine peat" has been made at Orlando, Orange County.

Phosphate rock. In 1911, production was 2,436,248 long tons of land pebble and hard rock phosphate, quarried in Alachua County, at Clark, Newberry, and elsewhere; Citrus County, Floral City, Hernando, and Istachatta; Columbia County, Fort White; Hernando County, Bay City; Hillsboro County, Plant City; Marion County, Anthony and Dunellon; Polk County, near Bartow, Fort Meade, Mulberry, and elsewhere; was formerly mined at Hull, De Soto County, and Buda, Orange County.

GEORGIA.

Abrasive. *See* Burrstone and Novaculite.

Agate. Fulton and Jones counties; not mined.

Aluminum. *See* Bauxite and Halloysite.

Amethyst. Rabun County, Ledbetter mine near Rabun Gap, stones of good color; North Georgia Co.'s mine 4 miles northwest of Clayton, good gems reported; Wilson prospect 4 miles southeast of Clayton. Reported also in Cobb and Oglethorpe counties.

Arsenopyrite. Cherokee County, at Canton mine and other places; Forsyth County, at Charles mine.

Asbestos. Habersham County, occurs at Hollywood; Hancock County, occurs at Sparta and many other places; Rabun County, has been mined at Hicks mine; White County, mined at Sall Mountain, near Nacoochee, shipped from Clarkesville.

Barite (heavy spar). Bartow County, present in nearly all ocher deposits of Cartersville district; mined at Cartersville, Emerson, and near Allatoona; Murray County, mined at Eton.

Bauxite. Occurs in northwestern part of the State, chiefly in Bartow and Floyd counties, and deposits are known extending from near Summerville or Adairsville to the Alabama State line. Cave Spring and vicinity have long been the center of the industry. Deposits are worked in the central part of the State near McIntyre, Wilkinson County, and have been discovered recently in Sumter County, near Andersonville.

Beryl. Rabun County, Beck beryl mine 7 miles east of Clayton. Large flawed crystals in pegmatite contain clear portions suitable for cutting.

Braunite. Bartow County, Cartersville district, mined with other manganese ores; Floyd County, small quantity in Cave Spring district.

Brown iron ore (limonite). Bartow County, extensively worked near Hermitage and other places in Barnsley district; Fannin County, Blue Ridge; Floyd County, extensive deposits in Cave Spring district, mined at Atkinson mine; Murray County, large deposits in sandstone ridges north of Cohutta Springs; Polk County, extensively mined near Cedartown, Ledbetter and Reed mines; Pulaski County, deposit at Hawkinsville; Whitfield County, openings near Tunnel Hill; reported in Gilmer, Gordon, Hall, Haralson, Milton, Whitfield, and other counties.

Burrstone (millstone). Bullock, Burke, Early, Jefferson, and Screven counties; has been quarried.

Cassiterite (tin ore). Lumpkin County, small quantity in placer gold near Dahlonega.

Cement material. Bartow County, limestone of Conasauga formation quarried for natural cement at Cement, 2 miles north of Kingston; Polk County, Rockmart and Davittes, Portland cement, limestone and slate used; Walker County, Chickamauga limestone used; natural cement at Rossville.

Chalcocite (copper glance). Cherokee County, Canton mine; other localities with chalcopyrite, not mined.

Chalcopyrite (copper pyrites). Cherokee County, Canton mine; Lincoln County, Phelps and Seminole mines; McDuffie County, Columbia mine and Landers prospect; has been mined in other localities in Carroll, Fannin, Fulton, Greene, Haralson, Lincoln, Lumpkin, Murray, Paulding (at Dallas), and Towne counties.

Chromite (chromic iron ore). Towne County, disseminated in minute crystals through chrysolite at Hog Creek near Hiawassee; fine exposures in Heard and Fayette counties; not mined.

Clay (brick). Extensive deposits in all parts of the State. Dug at many places. The production of common brick in 1911 was valued at $1,692,610.

Clay (paper). Glascock County, deposits near Gibson; Randolph County, Moyce property, 5½ miles north of Cuthbert; Richmond County, Hephzibah, 9 miles southwest of Augusta; Taylor County, Butler clay mine, 2½ miles west of Butler, shipped to northern markets; Twiggs County, near Dry Branch, Georgia kaolin mines; Wilkinson County, 1 mile west of Lewistown.

Clay (pottery). Developed deposits: Columbia County, pits at Groveton; Crawford County, Williams Mill, 6 miles east of Roberta; Hall County, small potteries at Oakwood and Gillsville operated at times; Oconee County, Bogart; Polk County, small quantity near Aragon; Twiggs County, Georgia kaolin mines near Dry Branch; White County, number small potteries operated at times. Undeveloped deposits: Chattooga County, small deposit near Menlo; Clarke County, 5 miles west of Athens; Glascock County, near Gibson; Washington County, Gilmore property, 10 miles north of Oconee; Wilkinson County, 3 miles northwest of McIntyre.

Coal (bituminous). Chattooga County, small area in northern part of county, not mined; Dade County, 3 workable seams in Lookout sandstone (Dade, Rattlesnake, and White Ash), mined near Cole City and in limited quantity near Rising Fawn; Walker County, coal confined to Pigeon Mountain, and east side Lookout Mountain, in Walden sandstone and Lookout sandstone, mined at Durham mine, 12 miles south of Chattanooga, Tenn.

Copper. *See* Chalcocite, Chalcopyrite, Covellite, and Malachite.

Corundum. Found in quantity at only few places. Prospecting as follows: In Cobb County, 2 miles south of Powder Springs; Forsyth County, 1 mile north of Sheltonville and elsewhere; Habersham County, Aleck Mountains; Hall County, in stream 1 mile west of Gainesville; Heard County, in magnesian rocks at Centralhatchee; Lumpkin County, 1 mile southeast of Porter Springs; Paulding County, has been mined in northeastern and southeastern corners of county; Rabun County, at Stone mine and Laurel Creek mine; Towns County, Bell Creek, Foster, and other mines (17th–18th districts); Troup County, sparingly near West Point; Union County, Track Rock mine; Upson County, 8 miles southwest of Thomaston; Walton County, near Monroe.

Covellite (indigo copper). Cherokee County, at Canton mine, with chalcopyrite and chalcocite, not mined.

Diamond. Four-carat diamond was found in Clayton County. Few finds in Hall and White counties.

Diopside. Pickens County, Southern marble quarries.

Fuller's earth. Columbia County, near Groveton, not mined; Decatur County, mined at Attapulgus; Twiggs County, mined at Pikes Peak.

Galena (sulphide of lead). Gwinnett County, abundant in Piedmont mine, argentiferous; Lincoln County, in small quantities at Ramsey property, abundant in Paschal and Phelps mines; McDuffie County, Columbia mine and Landers prospect.

Garnet. Lumpkin County, near Dahlonega. Abundant in garnet schists, and in gangues of some gold ores in Cherokee, Lumpkin, and other counties.

Genthite (nickel silicate). Towns County, with millerite, not mined.

Gneiss (biotite). Troup County, quarried 1 mile west of Mountville for macadam.

Gneiss (hornblende). Meriwether County, Tignor quarry.

Gold (placer). Bartow County, old placer mines on Gold Branch; Campbell County, Camp property, 8th district; Cherokee County, Cherokee, Kellogg, Sixes, and other mines; Cobb County, old placer mines; Coweta County, Bingham and Hill properties; Dawson County, old mines, Harris Branch and others; Douglas County, limited amount of mining at Roach mine; Elbert County, along stream courses within few miles of Bowman; Fannin County, Rantze Hill mine near Noontootly Creek, found about 12 miles southeast of Blue Ridge; Forsyth County, Faver mine; Gilmer County, White Path mine, 6 miles northeast of Ellijay, worked at intervals; Gwinnett County, considerable placer work was done on Richland Creek and tributaries; Habersham County, little work near Chattahoochee River in southeastern part of county, Nicholas mine 6 miles east of Clarkesville and few places along Soque River; Hall County, old prospects along creek emptying into Chattahoochee River in vicinity of Gainesville; Haralson County, old mines in 8th district; Hart County, small placer deposits mined on Red Hollow Road about 4 miles from Bowersville; Lumpkin County, Etowah, Josephine, and other mines were worked; Madison County, small deposits on Smith property, Webb, etc.; Meriwether County, small mine on Post property; Milton County, old mines; Murray County, Cohutta mine 4 miles east of Chatsworth; Newton County, 7 miles southwest of Covington; Paulding County, Austin mines 7 miles southeast of Dallas, Yorkville and Dunaway mines irregularly worked; Rabun County, considerable mining on Pages Creek and Lawground Branch; Towns County, Hightower Creek belt in vicinity of Visage northeast to near Georgia-North Carolina line, mining confined to Hightower Creek; Union County, extensive mining along Coosa Creek; Walton County, Malcome, Smith, and other mines have been worked; White County, Longstreet, Loud, and other mines, extensively worked.

Gold (lode). Bartow County, was mined at Glade mine; Cherokee County, Cherokee mine worked at times, Franklin mine near Creighton large producer, other mines; Cobb County, was mined at Mason mine 8 miles northeast of Dallas, and at Freeman mine near Acworth; Coweta County, prospecting on Clarke property near Hollingsworth Ferry; Dawson County, at Harris Branch, Magic, and other mines; Douglas County, at Pine Mountain; Forsyth County, at Strickland mine and elsewhere; Green County, about 6 miles northeast of Union Point; Gwinnett County, important mining operations in vicinity of Buford; Habersham County, Royal mine near Walkers Creek, 3 miles southeast of Tallapoosa, old prospects near Clarkesville, and near Chattahoochee River, in southeastern part of county, and at Hood and Nichols mines; Hall County, Odum and Potosi mines worked at intervals; Hart County, Brown mine, 6 miles south of Bowersville; Lincoln County, Paschal mine; Lumpkin County, Findley, Hedwig, Lockart, Preacher, Singleton, Whim Hill, and other mines, free and in quartz, mined at several points in Dahlonega and Auraria districts, and on Yahoola Creek and Chestatee River; McDuffie County, Columbia mines and others worked; Meriwether County, was mined at Wilkes and Lone Oak mines; Milton County, prospecting 4 miles from Sheltonville; Oglethorpe County, Buffalo, Guarantee, and Morgan mines—last worked; Paulding County, free gold reported from Sheffield property near Huntsville; Rabun County, Lamar, Moore, and other mines; Towns County, Greater Pittsburg and Nancy Brown mines; Union County, Legal Tender; White County, Loud mine, 4 miles southwest of Cleveland, many old mines worked at intervals; Wilkes County, Latimer mine (free gold) and Stone Ridge mine worked at intervals.

Granite (building and monumental). Bibb County, quarried at Macon; Campbell County, fine-grained medium light-gray biotite granite was quarried near Fairburn; Cobb County, Austell; Coweta County, several quarries in vicinity of Newnan; Dekalb County, dark blue-gray biotite granite, Congress and Lithonia quarries, and at many quarries on Stone Mountain; Elbert County, medium light-gray biotite granite in Elbertson area, several quarries; Fayette County, near Fayetteville, coarse-grained biotite granite; Hancock County, near Sparta; Heard County, Flat Rock at Wynn quarries near Franklin, fine-grained biotite granite; Madison County, Brown & Deadwyler quarries; McDuffie County, near Thomson, fine-grained biotite granite; Meriwether County, dark blue-gray medium-fine biotite granite quarried near Greenville; Oglethorpe County, dark blue-gray and light-gray fine, even-grained biotite granite quarried near Lexington; Oglethorpe and Madison counties, Oglesby area, superior fine-grained dark-blue biotite granite, 6 quarries; Putnam County, massive, fine, evengraimed dark blue-gray biotite granite quarried near Eatonton; Spalding County, medium coarse-grained light gray, at Griffin and Turner.

Granite (crushed stone). Henry County, quarried for crushed stone at Stockbridge; Stephens County, 3 miles from Toccoa; Troup County, Hogansville.

Granite gneiss. Clark County, quarried at Athens; Dekalb County, Rock Chapel Mountain quarries near Lithonia and Floyd quarry near Redan; Gwinnett County, Sawyer quarry; Jackson County, Saunders and Stanton quarries near Winder; Meriwether County, Odessa quarry near Greenville; Newton County, Freeman quarry near Covington; Oglethorpe County, extensive exposures coarse to fine-grained 3½ miles northeast of Lexington, suited for road work and masonry; Richmond County, biotite granite gneiss quarried near Augusta, rough work; Rockdale County, Powell, Turner, and other quarries; Walton County, near Loganville.

Granite porphyry. Columbia County, undeveloped, near Appling; Greene County, extensive body about 10 miles south of Greensboro; Lumpkin County, several exposures near Dahlonega; Morgan County, few outcrops, principal one on Hard Labor Creek, 5 miles northwest of Madison; Pike County, granular to porphyritic granite, dark gray, 9 miles west of Zebulon; also in Muscogee and Wilkes counties.

Graphite (plumbago). Bartow County, extensive deposits of graphitic slate for fertilizer filler mined near Emerson; Cobb County, was mined at Powder Springs. Occurs in Carroll, Cherokee, Clarke, Douglas, Elbert, Habersham, Hall, Heard, Madison, Paulding, Pickens, Rabun, and Spalding counties.

Halloysite. Chattooga County, 4½ miles northeast of Gore, extensively prospected; Dade County, near Rising Fawn, was mined and shipped; Floyd County, scattered through bauxitic clay in Holland Spring bank; Fulton County, near Lakewood, Atlanta; in Catoosa, Cherokee, and Walker counties, not mined.

Hematite (red ore, fossil ore). Bartow County, in minable quantities between Emerson and Etowah rivers, also near Warford, not mined; Catoosa County, abundant as float ore in Dicks Ridge, also occurs in Taylors Ridge and White Mountain; Chattooga County, mined along base of Lookout Mountain and 3½ miles east of Summerville, also on Dirtseller Mountain; Dade County, mined on Johnson Creek; Polk County, occurs north of Rockmart; Walker County, mined at West property, tenth district; has been mined also in Floyd and Whitfield counties.

Hematite (specular iron ore). Cherokee County, occurs in Allatoona hills, along Etowah River, extensive deposits; also in valley of Etowah River, in Bartow, Cass, Cobb, Fannin, Floyd, Gilmer, Lumpkin, Milton, Murray, Paulding, Pickens, Towns, and Union counties.

Hyalite. *See* Opal.

Iron. *See* Brown iron ore, Chromite, Hematite, Magnetite, Ocher, and Pyrite.

Itacolumite (flexible sandstone). Hall County, Chattahoochee Ridge; Meriwether County, near Warm Springs.

Kaolin (true and plastic). Developed: Bartow County, Sheet mine, 3 miles south of Adairsville; Greene County, small quantity mined 4 miles northeast of Union Point; Houston County, small mine on Yancey property 2 miles northwest of Perry; Richmond County, in clay bed at Hephzibah, 9 miles southwest of Augusta; Twiggs County, Georgia kaolin mine, 2 miles southeast of Dry Branch, and other mines. Undeveloped: Columbia County, deposits located 1 mile east of Grovetown; Glascock County, large deposit near Gibson; Hancock County, Carrs Station; Jones County, Griswoldville, 11 miles east of Macon; McDuffie County, 3 miles southwest of Dearing; Paulding County, prospecting at old Turner mica mine, 5 miles north of Dallas; Pickens County, in vicinity of Jasper; Polk County, Ledbetter mine; Taylor County, Butler.

Kaolin (porcelain clay). Undeveloped deposits in Baldwin, Cherokee, Fulton, Heard, and other counties in the crystalline area.

Lead. *See* Galena and Pyromorphite.

Lazulite. Lincoln County, Graves Mountain, not mined.

Limestone (building). Catoosa County, quarried at Graysville; Walker County, Chickamauga and Rossville.

Limestone (crushed stone). Bartow County, quarried at Cartersville and Clifford; Catoosa County, Graysville; Walker County, Chickamauga.

Limestone (flux). Walker County, quarried at Chickamauga.

Limestone (lime). Bartow County, quarried at Cartersville; Catoosa County, Graysville; Hall County, Gainesville; Walker County, Rossville.

Limonite. *See* Brown iron ore.

Magnetite (magnetic iron ore). Cherokee County, found in marble at Mabel station, 6 miles northeast of Canton; Carroll County, near Villa Rica, no well defined vein. Occurs also in Cherokee, Cobb, Dekalb, Gilmer, Greene, Gwinnett, Habersham, Hall, Lumpkin, and other counties; not mined.

Malachite (green carbonate of copper). Fannin County, mines of Ducktown, Tenn., belt.

Manganese ore. Occurs with brown and manganiferous iron ores in area of Paleozoic rocks which includes 10 northwestern counties of State. Bartow County, mined in Cartersville district; Fannin County, small deposits were mined at Blue Ridge; Floyd County, mined in Cave Springs district; Habersham County, has been mined at Mount Airy; Haralson County, small deposits in Draketown district; Hart County, mined 1½ miles east of Bowersville; Murray County, occurs with iron-ore deposits 4 miles north of Cohutta Springs; Paulding County, has been mined in Draketown district; Polk County, mined in Cave Springs district; Whitfield County, mined in vicinity of Tunnel Hill. *See also* Braunite, Manganite, Psilomelane, Pyrolusite, Rhodochrosite, and Wad.

Manganite. Bartow County, associated with psilomelane and pyrolusite in Cartersville mines, not mined.

Marble. Cherokee County, extensive exposures of dark-colored marble near Mabel Station and on Longswamp Creek; Gilmer County, extensive exposures, pink and white, quarried at Marble Bluff; Pickens County, white marble, quarried at Tate and at Southern Marble quarries, Marble Hill, Kenesaw, Piedmont, and other quarries 4 miles east of Tate; Polk County, white marble near Van Wert, not quarried; Whitfield County, dark chocolate grayish marble in northwestern corner of county; colored marbles in Bartow, Catoosa, Chattooga, Floyd, Gordon, Polk, and Walker counties.

Marl. Occurs in Bibb, Bullock, Burke, Charlton, Chatham, Chattahoochee, Clay, Crawford, Effingham, Emanuel, Houston, Jefferson, Pulaski, Quitman, Randolph, Screven, Stewart, Thomas, and Washington counties; not mined.

Mica (muscovite). Cherokee County, occurs in marble near Mabel Station 6 miles northeast of Canton; Elbert County, has been mined at Elberton; Fannin County, found near junction of Cutcane and Hempton creeks; Hall County, has been mined near Gainesville; Lumpkin County, mined near Tworun; Pickens County, common in marble; Rabun County, 10 miles east of Clayton; Union County, mined near Blairsville and 9 miles from Dahlonega; has been mined at Gaddistown, Quebec, and Ward Gap; also occurs in Carroll, Gwinnett, Heard, Towns, and Warren counties.

Millstone. *See* Burrstone.

Mineral paint. *See* Ocher.

Nickel. *See* Genthite.

Novaculite (oilstone). Undeveloped beds in Heard, Lincoln, McDuffie, Meriwether, Oglethorpe, and Troup counties.

Ocher (mineral paint). Bartow County, mined extensively near Cartersville, large plants.

Oilstone. *See* Novaculite.

Opal. Fire opal is found in Bullock and Washington counties; hyalite in Burke, Rabun, and Screven counties.

Psilomelane. Bartow County, important ore of Cartersville district; mined near Cartersville, Emerson, and Rowland Spring.

Pyrite. Bartow County, occurs in quartzite in Cartersville district; Carroll County, mined near Bremen, at Reids Mountain, and at Villa Rica; Cherokee County, mined at Ball Ground and near Creighton; Cobb County, mined at Acworth; Dawson County, occurs in large quantities on Shelton property; Greene County, small quantities in east part of county; Haralson County, mined near Westbrook, Draketown district; Lumpkin County, mined 6 miles northeast from Dahlonega; McDuffie County, occurs in considerable quantities in Columbia mine and Landers prospect; Murray County, occurs near Cohutta; Oglethorpe County, occurs in large quantities in quartz in Guarantee and Morgan mines; Paulding County, has been mined near Hiram; White County, occurs in large quantities in Blake mine.

Pyrolusite (black manganese oxide). Bartow County, important ore in Cartersville district, mined near Cartersville, Emerson, and Rowland Spring; Catoosa County, occurs but not mined; Fannin County, occurs with brown iron ores 10 miles northeast of Blue Ridge; Floyd County, important ore of Cave Spring district, mined in several places; Paulding County, occurs in residual mica schist clay in Draketown district; Whitfield County, occurs but not mined.

Pyromorphite. Lincoln County, at few points in Seminole mine; McDuffie County, occasionally found in oxidized vein of Columbia mine, not mined.

Quartz (rock crystal). Gem quality, occurs in Franklin, Forsyth, Fulton, Jones, Rabun, and Wilkes counties.

Rhodochrosite. Polk County, in iron mines near Cedartown; Towns County, in small quantity lining cavities several miles west of Hiawassee, not mined.

Road metal. Suitable material in northern part of State consists of the Knox dolomite and the Chickamauga and Bangor limestones. Chert deposits of Knox and Fort Payne formations. Granite, gneiss, diorite, schist, quartzite, and trap rock widely distributed.

Ruby. Rabun County, Laurel Creek mine; Towns County, Hiawassee mine; Union County, near Caldwell.

Sapphire. Rabun County, Laurel Creek mine.

Sand (building). Dug in Cobb County, Oakdale; Crawford County, Zenith; Floyd County, Rome; Fulton County, Bolton; Habersham County, Demorest; Henry County, Stockbridge; Monroe County, Popes Ferry; Muscogee County, Columbus; Taylor County, Howard; Telfair County, Lumber City; Walker County, Flintstone; Whitfield County, Dalton.

Sand (glass). Dug in Crawford County, Zenith; Montgomery County, Lumber City; Taylor County, Butler.

Sand (molding). Dug in Catoosa County, Ringgold; Gilmer County, Ellijay; Habersham County, Demorest; Newton County, Almon; Taylor County, Howard; Walker County, Flintstone; Whitfield County, Dalton.

Sandstone (flexible). *See* Itacolumite.

Serpentine. Cherokee County, quarried at Verde Antique Marble Quarry, Holly Springs. Occurs also in Rabun, Towns, and Union counties; not quarried.

Shale (brick). Catoosa County, occurs near Ringgold; Chattooga County, small quantity 3 miles west of Lyerly, mined and shipped; Floyd County, mined near Rome; Gordon County, mined at Calhoun; Murray County, Chatsworth; Walker County, Mission Ridge; Whitfield County, Conasauga shale, 3 miles southeast of Dalton, not used.

Silver. Small quantity recovered from placer and lode gold in Cherokee, Hall, Lumpkin, Paulding, and White counties.

Slate. Bartow County, quarried near Fairmount; Polk County, several producing quarries near Rockmart; was formerly quarried near Van Wert.

Soapstone. *See* Talc.

Sphalerite (zinc blende). Lincoln County, Seminole mine; not mined.

Sulphur. *See* Pyrite.

Talc (soapstone). Cherokee County, occurs near Ball Ground and Holly Springs; Fannin County, has been mined near Blue Ridge; Murray County, good grade of talc for burners and crayons, lower grade for grinding; mined at several places near Chatsworth. Undeveloped in Clayton, Cobb, Dekalb, Elbert, Fannin, Fulton, Gilmer, Hall, Habersham, Jasper, Paulding, Union, and White counties.

Tin. *See* Cassiterite.

Tourmaline. Rabun County, Laurel Creek corundum mine; Towns County, Hog Creek corundum mine near Hiawassee.

Tremolite. Fannin County, Park property near junction of Cutcane and Hampton creeks; Pickens County, Southern Marble quarries, near Tate.

Tripoli. Has been mined in Chattooga County, near Lyerly; Murray County, at Chatsworth and Spring Place; Whitfield County, near Dalton.

Verde antique. *See* Serpentine.

Wad. Bartow County, associated with psilomelane and pyrolusite in Cartersville manganese mines; not mined.

Zinc. *See* Sphalerite.

IDAHO.

Anglesite (lead sulphate). Found in surface ores of some of the argentiferous lead mines in Blaine County, at Sawtooth, Vienna, and Wood River; Custer County, at Bay Horse; Lemhi County, at Texas, and in other districts.

Antimony ore. Shoshone County, reported in ores of Stanley mine, near Burke, in the Cœur d'Alene district. Character not known. *See also* Cervantite and Stibnite.

Argentite. Occurs at the following places: Blaine County, Silver King and Vienna mines; Custer County, Bay Horse and Yankee Fork districts; Elmore County, Yuba City, Monarch mine at Atlanta and Banner mines; Idaho County, Warren district; Owyhee County, Black Jack, Trade Dollar, and other Silver City mines.

Arsenopyrite. Common in many mining districts; has been mined in the following places: Ada County, Black Hornet (Shaw Mountain) district, 8 miles east of Boise; Blaine County, mined for gold at North Star, Red Cloud, and Croesus mines; argentiferous near Ketchum; Boise County, mined for gold and silver at Gold Hill, Checkmate, Good Friday, and other claims in Willow Creek district; Bonner County, near Granite; Elmore County, Neal and Rocky Bar districts; Idaho County, Warren district; Washington County, Mineral district.

Asbestos (amphibole). Lewis County, has been mined 14 miles southeast of Kamiah.

Azurite. Blaine County, has been mined with lead ore in Wood River district; Custer County, has been mined with other copper ores; Elmore County, in Tahoma mine, Atlanta district; Oneida County, has been mined at Blackstone mine; Shoshone County, occurs in gangue of silver-lead ores near Mullan; abundant in Hunter; less so in Morning mine, and other mines and prospects.

Bornite. Bannock County, Moonlight property near Pocatello; Kootenai County, prospects on the east side of Lake Pend Oreille; Lemhi County, Copper Queen mine; Shoshone County, Snowstorm and Copper King mines, Cœur d'Alene district; Washington County, Weiser district; mined for gold and silver in Seven Devils district.

Brown iron ore (limonite). Common in outcrops of lode deposits in many mining districts; not mined for iron; used as flux at Muldoon, Blaine County.

Cassiterite. Occasionally found in Jordan Creek and other streams, Bitterroot Mountains; in Lemhi County, on Panther Creek; and in Shoshone County, in the Cœur d'Alene district.

Cerargyrite (horn silver). Has been mined in the following places: Blaine County, surface ore in Wood River district; Custer County, Bay Horse district; Elmore County, surface ore of Monarch lode, Atlanta, and Smoky district; Idaho County, Warren district; Lemhi County, districts in the southeastern part of the county; Owyhee County, De Lamar and Silver City districts. Reported from other districts.

Cerusite (lead carbonate). Common oxidized ore in silver-lead mines of: Blaine County, Wood River district; Custer County, Bay Horse and other districts; Lemhi County, Junction, Nicholia, Spring Mountain, and Texas Creek districts; Shoshone County, Cœur d'Alene district.

Cervantite (antimony ocher). Blaine County, has been mined in Wood River district.

Chalcanthite. Washington County, Mineral district, and in copper mines in other districts.

Chalcedony. Custer County, occurs in Yankee Fork district; Lemhi County, Gravel Range and Parker Mountain districts; Owyhee County, Silver City.

Chalcocite. Bannock County, Moonlight mine near Pocatello; Bear Lake County, in Triassic rocks near Montpelier; Fremont County, Sedalia mine; Shoshone County, mined for gold and silver in the Snowstorm mine, and in small quantity in the Park, Reindeer, and Carney copper prospects, Cœur d'Alene district; Washington County, Seven Devils district.

Chalcopyrite. Blaine County, mined for gold at Argent and Jay Gould mines, Wood River district. Boise County, rare in Willow Creek district. Custer County, chief ore of White Knob copper mine; auriferous in Lost Packer mine. Idaho County, Big Buffalo, Monte Cristo, and Jumbo mines, Buffalo Hump district; prospects near Harpster and Mount Idaho; carries gold and silver. Kootenai County, prospects east of Pend Oreille Lake. Owyhee County, mined for gold and silver at Black Jack and Trade Dollar mines, Silver City. Shoshone County, chief copper ore in Monitor mine, and many prospects of St.

Joe basin and Cœur d'Alene district; subordinate part of ore in Snowstorm mine. Washington County, Mineral and Seven Devils districts.

Cinnabar (sulphide of mercury). Custer County, in gold-bearing gravel, Willis placers, on Stanley Creek; Elmore County, stringers of cinnabar in granite are reported in the Pine mining district about 40 miles north of Mountain Home; Idaho County, Pringle-Smith prospect on Sugar Creek, 10 miles east of Roosevelt.

Clay (brick). Dug in the following places: Ada County, at Boise; Adams County, Meadows; Bannock County, Pocatello; Bear Lake County, Paris; Bingham County, Idaho Falls; Bonner County, Sandpoint and Albany Falls; Canyon County, Caldwell, Emmett, and Payette; Cassia County, Oakley; Fremont County, St. Anthony; Idaho County, Grangeville and Keuterville; Kootenai County, Cœur d'Alene and Huetter; Latah County, in Genesee, Hendrick, and elsewhere; Nez Perce County, in Ilo, Kippen, Lewiston, and elsewhere; Oneida County, Preston; Washington County, Weiser.

Coal. Bituminous coal has been mined in the eastern part of Bonneville and Fremont counties in an extension of the Sublette field of Wyoming. Lignite has been mined in the ridges between Horseshoe Bend and Jerusalem, Boise County, and near Salmon City, Lemhi County.

Cobalt. Lemhi County, occurs near Blackbird. *See also* Erythrite.

Copper. The predominant metal produced in the following districts: Adams County, Seven Devils district; Bannock County, Fort Hall; Bear Lake County, Bear Lake; Bonneville County, Mount Pisgah; Blaine County, Hamilton; Bonner County, East Shore (Clark Fork); Custer County, Alder Creek; Fremont County, Skull Canyon and Camp Howard; Lemhi County, Blackbird; Shoshone County, Bald Mountain and Black Prince; Washington County, Heath. Of minor importance in many other mining districts. *See also* Azurite, Bornite, Chalcanthite, Chalcocite, Chalcopyrite, Covellite, Cuprite, Malachite, Melaconite, and Tetrahedrite.

Copper (native). Shoshone County, rare in Snowstorm mine, Cœur d'Alene district.

Corundum (sapphire). Adams County, in concentrates from Rock Flat gold placer near Meadows. Clearwater County, various shades of blue and green in gravel deposits near Pierce, especially along Rhodes and Orofino creeks.

Covellite. Bear Lake County, small quantity near Montpelier; Shoshone County, in Last Chance mine of Cœur d'Alene district.

Cuprite (copper oxide). Shoshone County, in Snowstorm and Monitor mines, Cœur d'Alene district; Washington County, occurs in Weiser district; argentiferous at River Queen copper deposit, one-half mile above Ballards.

Dufrenoysite. Blaine County, with lead ores in considerable quantity in Wood River district; has been mined; Bonner County, occurs in Crown Point mine.

Erythrite. Lemhi County, near Blackbird.

Freibergite (argentiferous tetrahedrite). Blaine County, has been mined in Columbia, Pilgrim, and other mines in the Sawtooth district.

Galena. Blaine County, the principal ore of Wood River district, mined for lead and silver near Hailey, and elsewhere; Boise County, Checkmate, Good Friday, and other claims in Willow Creek district, mined for gold and silver; Bonner County, occurs with gold at Buckhorn mine, east of Mooyie River; Custer County, Bay Horse district, extensively mined, also in copper ores of White Knob mines; Elmore County, mined in Neal district for gold and silver; Idaho County, Little Giant, Rescue, and other mines in Warren district, for gold and silver; Big Buffalo and Monte Cristo mines, Buffalo Hump district; Kootenai County, mines and prospects on south and west sides of Lake Pend Oreille argentiferous; Snowshoe mine, near Troy; Lemhi County, Texas Creek, Junction, Spring Mountain, and Nicholia districts; extensively mined; Owyhee County, South Mountain, Black Jack, and Trade Dollar mines, Silver City; Shoshone County, chief ore of silver-lead mines, Coeur d'Alene district; associated with gold in Golden Chest and other mines near Murray; prospects in St. Joe basin; Washington County, mined for gold and silver in Mineral district, Blue Mountain gold belt.

Garnet (spessartite). Washington County, with bornite and powellite in Peacock claim, Seven Devils district.

Gold (lode). Predominant metal produced in the following districts: Ada County, Black Hornet and Boise (McIntire); Blaine County, Camas, Little Smoky, and Rosetta; Boise County, Highland Valley, Idaho City, Quartzburg, Summit Flat, and Westview; Bonner County, Mooyie Yaak, Blacktail, and Pine Creek; Cassia County, Connor Creek; Clearwater County, Musselshell Creek, and Pierce; Custer County, Loon Creek, Seafoam, Stanley Basin, Washington Basin, and Yankee Fork; Elmore County, Atlanta, Black Warrior, Neal, Pine Grove, and Rocky Bar; Idaho County, in nearly every district; Lemhi County, in nearly every district; Owyhee County, De Lamar and Mammoth; Shoshone County, Eagle (Murray), St. Regis, and Summit.

Gold (placer). The predominant metal produced in the following districts: Ada County, Snake River; Adams County, Meadows, 16 miles northeast of Evergreen; Bingham County, Snake River at Blackfoot, Rich, and Otis; Blaine County, Soldier and Snake River, near Wampi; Boise County, Moore Creek, Deadwood, Gold Fork, Payette River, and Twin Springs; Cassia County, Snake River; Clearwater County, Burnt Creek, Moose Creek; Elmore County, Highland Valley; Idaho County, Crooks Corral, Maggie, Salmon River, Kootenai County, Camas Cove; Latah County, Gold Creek and Moscow; Lemhi County, Kirtley Creek, Leesburg, Mackinaw, and Pratt Creek; Owyhee County, gravels of Snake River; Shoshone County, St. Joe, 25 miles west of Iron Mountain, Mont.

Granite. Boise County, quarried at Boise and elsewhere.

Hematite. Widespread in outcrops of lode deposits.

Hübnerite. Lemhi County, mined on Patterson Creek, Blue Wing district.

Iron. *See* Brown iron ore, Hematite, and Magnetite.

Lead (native). Blaine County, reported in Wood River district.

Lead minerals. Lead is the predominant metal in the following districts: Bear Lake County, St. Charles; Blaine County, Dome, Elkhorn, Galena, Muldoon, and Mineral Hill; Bonner County, Priest Lake; Custer County, East Fork, 24 miles west of Mackay; Fremont County, Little Lost River, 25 miles northeast of Arco; Lemhi County, Junction, Spring Mountain, and Texas Creek; Owyhee County, South Mountain, 46 miles south-southwest of Murphy; Shoshone County, Beaver, Evolution, Hunter, Leland, Pine Creek, Slate Creek, Wallace, and Yreka; Washington County, Mineral, 29 miles north-northeast of Huntington, Oregon. *See also* Anglesite, Cerusite, Galena, Massicot, and Pyromorphite.

Lignite. Boise County, has been mined near Horseshoe Bend; Cassia County, occurs in Goose Creek field; Lemhi County, has been mined near Salmon City.

Limestone (building). Quarried in Blaine County, at Ketchum and Arco; Fremont County, Rexburg; and Oneida County, Franklin.

Limestone (lime). Bannock County, burned at Pebble; Cassia County, Burley, Clearwater County, Orofino; Fremont County, Rexburg and Teton; Kootenai County, at Squaw Bay on Pend Oreille Lake.

Limonite. *See* Brown iron ore.

Magnetite (magnetic iron ore). Blaine County, occurs in Wood River country; Shoshone County, rare in ores of Cœur d'Alene district; Washington County, *occurs in Mineral* district, Blue Mountain gold belt.

Malachite (green carbonate of copper). Has been mined with other copper ores in Blaine County, Wood River district; Idaho County, Warren district; Washington County, Mineral and Seven Devils districts.

Marble. Cassia County, small quantity quarried at Little Basin.

Marcasite. Has been mined for gold and silver: Blaine County, in Wood River district; and Owyhee County, in Trade Dollar mine, Silver City.

Massicot. Shoshone County, oxidized lead ore in Cœur d'Alene district; Hercules, California, and other mines.

Melaconite. Washington County, was mined with other copper minerals in Seven Devils district.

Mica. Adams County, was mined 15 miles from Council; Cassia County, prospecting 30 miles from Albion; Idaho County, prospecting at Pardee; Latah County, prospecting at Avon and Troy.

Monazite. Ada County, occurs in black sands at Boise and Boise Basin; Adams County, Meadows, Snake River, and John Day Creek; Boise County, in black sands at Placerville, Idaho City, and elsewhere; Canyon County, Payette River; Clearwater County, Orofino, Dent, and elsewhere; Lemhi County, at Leesburg; Lincoln County, at Minidoka; Owyhee County, at Oreana.

Nickel ore. Lemhi County, deposits at Blackbird.

Phosphate rock. Bannock County, occurs in many parts of the county; Bear Lake County, near Georgetown, Montpelier, and Paris; Bingham County, along Snake River; Bonneville County, on Pine Creek and along the State line; Fremont County, along the State line southeast of St. Anthony.

Platinum. Found in small quantity (no production reported in 1910 and 1911) in black sands of Boise, Idaho, and Shoshone counties, and also in the following localities: Ada County, Payette River; Bingham County, Snake River; Clearwater County, Pierce City district; Elmore County, Rocky Bar; Idaho County Elk City district; Nez Perce County, North Fork, Clearwater River.

Polybasite. Owyhee County, occurs at Silver City.

Proustite (light ruby silver). Blaine County, associated with pyrargyrite in Sawtooth and other districts; Elmore County, in Monarch and Buffalo mines, Atlanta; Owyhee County, has been mined at Silver City; Shoshone County, in Cœur d'Alene district.

Pumice. Oneida County, has been mined at Rockland.

Pyrargyrite. Blaine County, has been mined in Wood River district; Boise County, has been mined in small quantity for gold and silver in Banner silver veins; Idaho County, in Warren district; Owyhee County, in De Lamar district.

Pyrite. Boise County, mined for gold and silver at Checkmate, Gold Hill, and other veins in Willow Creek district; Custer County, important ore of White Knob copper mine; Elmore County, in Neal district; Idaho County, at Big Buffalo and Jumbo mines in the Buffalo Hump district; Lemhi County, at Gibbonsville and elsewhere; Shoshone County, found in all deposits of Cœur d'Alene district; mined for gold at Golden Chest mine, north of Littlefield; Washington County, at Mineral silver mines, Blue Mountain region.

Pyromorphite. Shoshone County, Cœur d'Alene district; mined at Idaho Giant and other prospects.

Pyrrhotite. Blaine County, has been mined in Croesus, Camas, and Tip Top mines, Wood River district; Lemhi County, in ores of Blackbird and Indian Creek districts; Shoshone County, Cœur d'Alene district, and in copper veins of St. Joe Basin.

Salt (brine). Bannock County, Stump Creek and Tygee valleys, west of Star Valley.

Salt (rock). Bannock County, mined on southeast side of Crow Creek valley, 38 miles northeast of Montpelier; Bear Lake County, mined on Crow Creek.

Sand and gravel. Ada County, dug at Boise and Idaho Falls.

Sandstone. Quarried in the following localities: Ada County, at Boise and Table Rock; Bonneville County, at Elva, Idaho Falls, and Willow Creek; Fremont County, at Sunnydell.

Scheelite. Blaine County, small quantity reported from North Fork mining district, northeast of Ketchum; Idaho County, has been mined for gold and silver in the Warren mining district; Lemhi County, found as secondary mineral in Bluewing district; Shoshone County, found in Golden Chest and Golden Winnie mines, near Murray.

Silver. The predominant metal produced in the following districts: Blaine County, Antelope, Lava Creek, Sawtooth, and Warm Springs; Boise County, Banner; Bonner County, Kootenai, 40 miles northwest of Iola; Custer County, Bay Horse and Sheep Mountain; Kootenai County, Lakeview and Medimont; Lemhi County, Bluewing and Parker Mountain; Owyhee County, Carson and Flint. Silver is of only less importance in many other districts. *See also* Argentite, Cerargyrite, Polybasite, Proustite, and Pyrargyrite.

Silver (native). Shoshone County, associated with cerusite in Last Chance mine, Cœur d'Alene district; rare; and in oxidized portion of many lodes in the State but nowhere is an abundant ore.

Specularite. Idaho County, streaks through ore at Peacock claim, Seven Devils district.

Sphalerite (zinc blende). Blaine County, mined for gold and silver at Silver King and Vienna mines; Boise County, Gold Hill, Good Friday, Checkmate, and other veins in Willow Creek district; Custer County, occurs with lead-silver ores; Elmore County, small quantity in Neal district; Idaho County, Monte Cristo, and other mines in Buffalo Hump district, and Little Giant, Rescue, and other mines in Warren district; Lemhi County, occurs with lead-silver ores; Owyhee County, Silver City and South Mountain; Shoshone County, associated with galena, etc., in some mines in the Cœur d'Alene district, save at Success and Morning mines; Washington County, Mineral district.

Stibnite. Blaine County, occurs in Wood River district; Boise County, occasionally found at Gold Hill; Elmore County, occasionally found in the Neal district; Shoshone County, has been mined in George Gulch, 1 mile from Burke; carries gold.

Sulphur. Bannock County, sulphur springs deposit near Soda Springs; has been mined.

Tetrahedrite (gray copper ore). Has been mined in the following localities: Blaine County, intergrown with galena in number of mines in the Wood River district; Custer County, great deposits in Bay Horse district; Elmore County, small quantity in Banner mines; Idaho County, mined for gold and silver at Big Buffalo, Jumbo, and other mines in Big Hump district, and at Little Giant, Rescue, and other mines in Warren district; Owyhee County, small quantity at Flint, Silver City; Shoshone County, at some lead-silver mines in the Cœur d'Alene district; Washington County, at Mineral silver mines, Blue Mountain gold belt.

Tin. *See* Cassiterite.

Tungsten. *See* Hübnerite and Scheelite.

Zinc. *See* Sphalerite.

ILLINOIS.

Cement material. Large deposits suited for development. Those developed are: Clark County, "Lower Magnesian" (Ordovician) limestone mined for natural cement near Utica; Cook County, blast-furnace slag and crushed limestone used for Portland cement at Chicago; La Salle County, Pennsylvanian ("Coal

Measures") limestone quarried for Portland cement material at Oglesby and east of La Salle; Lee County, "Trenton" limestone quarried at Dixon for Portland cement.

Cerusite (carbonate of lead). Jo Daviess County, secondary mineral of lead-zinc mines.

Clay (brick). Clay suitable for brickmaking is dug at one or more places in practically every county in the State. The value of common brick produced in Illinois in 1911 was $6,129,911. Total clay products were valued at over $14,500,000.

Clay (fire). Dug in Alexander County, at Elco; Calhoun County, Golden Eagle; Fulton County, Avon; Green County, 2¼ miles northeast of Whitehall, and at Drake; Grundy County, at Coal City; La Salle County, near Streator, Utica, and Ottawa; Livingston County, 1½ miles south of Streator; McDonough County, 1 mile north of Macomb; Pope County, on branch of Robustle Creek; Rock Island County, at Carbon Cliff; Scott County, Alsey; Union County, Kaolin and Jonesboro; Warren County, Monmouth; Winnebago County, Rockton.

Clay (kaolin). Pope County, has been dug at Raum; Union County, dug at Kaolin.

Clay (paper). Pulaski County, occurs at Pulaski.

Clay (pottery). Pits in Green County, at Drake (ball clay also dug); La Salle County, Lowell; Massac County, Round Knob; McDonough County, Colchester; Pulaski County, Yates Landing and near Lockharts Landing; Rock Island County, Carbon Cliff; Warren County, Monmouth.

Coal (bituminous). Nearly three-fourths of the State is underlain by productive coal measures, the total area being estimated at 35,600 square miles. Fifty-one counties reported some coal production in 1911. Sangamon and Williamson counties produced over 5,000,000 short tons each; Macoupin County exceeded 4,000,000 tons; and five other counties, Franklin, Madison, St. Clair, Saline, and Vermilion, produced over 3,000,000 tons each. The total production of the State in 1911 was 53,679,118 short tons, valued at $59,519,478.

Flagstone. Alexander County, Thebes; Madison County, Alton; Monroe County, Columbia and Monroe; Wayne County, Fairfield; Will County, Joliet, Twelve-Mile Grove, and Wallingford; in Calhoun, Hamilton, Pike, Scott, Wabash, White, and other counties.

Fluorspar. Hardin County, mined in Rosiclare and Hicks district, at Cave-in-Rock, Fairview Landing, and elsewhere; Pope County, mined at Pittsburg, McClellan, and other mines.

Galena. Hardin County, occurs in small bunches in fluorspar at the Fairview mine, also in Empire mine; Jo Daviess County, occurs in numerous mines. Produced as by-product in cleaning fluorspar at Empire, Rosiclare, and other mines.

Geodes. Hancock County, abundant in shale at Warsaw.

Lead. *See* Cerusite and Galena.

Limestone (building). Quarried in Adams County, at Front, Jefferson, and Quincy; Boone County, Belvidere; Carroll County, Savanna; Cook County, at Lemont, Sag Bridge, and elsewhere; Jersey County, Grafton; Jo Daviess County, Galena and near Woodbine; Kane County, Batavia; Kankakee County, Momence; La Salle County, La Salle; McHenry County, Marengo; Madison County, Alton; Monroe County, Maeystown and Millstadt Junction; Ogle County, Mount Morris; Randolph County, Menard; Will County, near Lemont, and Joliet; Winnebago County, Rockford and Pecatonica.

Limestone (crushed stone). Quarried in Adams County, at Quincy; Boone County, Belvidere; Carroll County, Savanna; Cook County, Bellwood, Chicago, Summit, and elsewhere; Dupage County, Elmhurst; Hancock County, near Niota; Jersey County, Elsah and Grafton; Kane County, Batavia and South Elgin;

Kankakee County, Kankakee and Momence; La Salle County, La Salle; Lee County, Dixon; McHenry County, Marengo; Madison County, Alton; Monroe County, Millstadt Junction; Montgomery County, Hillsboro; Ogle County, Rochelle; Pike County, Valley; Randolph County, Menard; Rock Island County, Port Byron and Moline; St. Clair County, Belleville, Falling Springs and Stolle; Union County, Anna; Whiteside County, Fulton and Sterling; Will County, Elwood and Joliet; Winnebago County, Rockford and Rockton.

Limestone (fertilizer). Good limestone for fertilizer occurs in Alexander County, along river bluff one-half mile south of Thebes; Coles County, near Charleston; Hardin County, Rosiclare; Johnson County, Belknap; Pulaski County, near Ullin; Union County, Anna.

Limestone (flux). Quarried in Adams County, at Quincy; Cook County, Chicago; Jersey County, Elsah; Monroe County, Millstadt Junction; Vermilion County, Fairmount; Will County, Joliet.

Limestone (lime). Quarried in Adams County, at Marblehead and Quincy; Cook County, many points in vicinity of Chicago; Jo Daviess County, Stockton; Kankakee County, Kankakee; Madison County, Alton; Monroe County, New Hanover; Rock Island County, Port Byron; Whiteside County, Fulton; Will County, Joliet; Winnebago County, Rockford.

Natural gas. Gas was produced in 1911 in the following counties: Bond, Bureau, Champaign, Clark, Crawford, Cumberland, De Witt, Edgar, Lawrence, Lee, Logan, McHenry, McLean, Macoupin, Morgan, and Pike. There were 458 productive wells at the close of the year.

Peat. Occurs in Boone County, Boone Township; Bureau County, Gold Township; Cook County, in several localities; Kane County, Carpentersville, Hampshire and Rutland; La Salle County, west of Utica; in Lee, Lake, and McHenry counties; Ogle County, Monroe; Stephenson County, Florence; Whiteside County, in Cattail Slough, very large body. In glacial drift 50 to 90 feet below surface, of variable quality, most commonly only a soil rich in humus.

Petroleum. The principal oil-producing counties in 1911 were: Clark, with 60 square miles of productive territory; Crawford, 110 square miles; Cumberland; Lawrence, 40 square miles. There are small fields at Carlisle, Clinton County; Centralia and Sandoval, Marion County; Carlinville, Macoupin County; and other places. Up to the close of 1911 about 16,000 wells had produced oil. The yield for 1911 was 31,317,038 barrels.

Pyrite. Hardin County, occurs in small quantities in Fairview, Empire, and other mines; Jo Daviess County, with galena and sphalerite in lead-zinc mines.

Sand (building). Dug in Alexander County, at Cairo; Bond County, Greenville; Boone County, Belvidere; Bureau County, Buda and Wyanet; Carroll County, Savanna; Cook County, Lake Michigan and Worth; Dekalb County, Genoa; Dupage County, Warrenville; Henderson County, Gladstone; Jo Daviess County, East Dubuque; Kane County, Aurora, Carpentersville, and elsewhere; Kendall County, Millington; Lake County, Antioch, Beach, and elsewhere; La Salle County, La Salle, Ottawa, and Wedron; Lee County, Dixon; Logan County, Kickapoo Creek and Lincoln; McHenry County, Algonquin and Cary Station; Madison County, Alton; Mercer County, Keithsburg; Ogle County, Hazlehurst and Woosung; Peoria County, Peoria; Piatt County, Hammond; Rock Island County, Moline; Tazewell County, Pekin; Whiteside County, Galt, and near Sterling; Will County, Joliet, Millsdale, and Plainfield; Winnebago County, Rockford and South Beloit; and at other places.

Sand (glass). Bond County, pits at Greenville; Calhoun County, Cap au Iris; Kendall County, Millington; La Salle County, important quarries in St. Peter sandstone at Ottawa, Utica, and Wedron; Lee and Ogle counties, occurs along Rock River.

Sand (molding). Pits in Alexander County, at Cairo; Bond County, Greenville; Bureau County, Wyanet; Fayette County, Vandalia; Hancock County, Niota; Henderson County, Gladstone; Kane County, Aurora, Batavia, and Elgin; Kendall County, Millington; La Salle County, Ottawa, Utica, and Wedron; Lee County, Pit; McHenry County, Algonquin; Madison County, Collinsville and East Alton; Jackson County, Cora; St. Clair County, East St. Louis and French Village; Shelby County, Cowden; Tazewell County, Pekin; Whiteside County, Round Grove; Will County, Joliet; Winnebago County, Rockton.

Sand and gravel. Abundant and used in many counties for making concrete.

Sandstone. Quarried in Alexander County, at Elco; Carroll County, Savanna; Clay County, Xenia; Fulton County, Lewistown and Marietta; Henry County, Colona; Lee County, Ashton; Union County, small quantity 6 miles east of Anna. Was formerly quarried in Jackson County, Drury Creek; Peoria County, Kickapoo River; Rock Island County, Andalusia; St. Clair County; Sangamon County, west of Springfield; Warren County, Berwick and Greenbush.

Siderite (iron carbonate). Crawford County, Palestine; Edwards County, T. 1 S., R. 10 E.; Hardin County, Sellers Landing; Schuyler County, Sugar Creek, T. 2 N., R. 1; Wayne County, at several localities. These and other localities in Pennsylvanian ("Coal Measures") rocks; beds from 1 to 2 feet thick, generally poor.

Silica (amorphous). Alexander County, mined near McClure; Union County, mined near Jonesboro, Reynoldsville, and Wolf Lake.

Silver. Hardin and Pope counties, recovered from lead concentrates in fluorspar district.

Smithsonite. Jo Daviess County, mined in Galena district.

Sphalerite (zinc blende). Jo Daviess County, principal ore of Galena district. Hardin and Pope counties, small quantities are obtained as a by-product in cleaning fluorspar, though none has been marketed from this region.

Tripoli. Union County, large production from Anna, Jonesboro, and Westlake; refineries at Jonesboro and near Westlake; lesser occurrences elsewhere.

Zinc. *See* Smithsonite and Sphalerite.

INDIANA.

Abrasive. *See* Grindstone, Oilstones, and Whetstones.

Asphalt. Gibson County, bed several feet thick in deep well near Princeton; also seeps into bottom of a coal mine in considerable quantity at same place.

Brown iron ore (bog iron ore, limonite). Clay County, Harmony and in T. 10 N., R. 6 W.; Daviess County, several localities; Greene County, vicinity of Cincinnati and along creeks; Lawrence County, a few workable deposits; Martin County, south of Shoals near Coal Hollow, extensive deposits near Baltimore & Ohio Southwestern Railroad have been mined; Monroe County, small deposits along Indian Creek, formerly used in furnaces; Noble County, Ore prairie; Orange County, in many hills; Vermilion County, Nortons Creek and Hilton prairie; occurs also at several localities in Jasper, Kosciusko, La Porte, and St. Joseph counties but is not mined.

Cement material (Portland). Plants are operating on local deposits of marl in Lagrange County, at Stroh; and in Kosciusko County, at Syracuse; on limestone in Lawrence County, at Mitchell. Limestone worthy of consideration as source of cement material occurs in three geologic divisions: Cincinnatian series (Upper Ordovician), only in southeastern Indiana, occupying all or part of Dearborn, Fayette, Franklin, Jefferson, Ohio, Ripley, Switzerland, Union, and Wayne counties. Mississippian series (lower Carboniferous), in belt 20 miles wide from Harrison County on Ohio River northwest to Benton County.

Pennsylvanian series ("Coal Measures" or upper Carboniferous), in southwestern part of State; 14 counties underlain, and some coal found in 12 others. *See also* Marl, which is suitable for Portland cement.

Cement material (natural). Clark County, Devonian hydraulic limestone quarried and burned for natural cement at Sellersburg, Belknaps, Speeds, Watson, and Charlestown.

Clay (brick). Indiana ranked seventh in brick produced in the United States in 1911; practically every county in the State has at least one brickyard.

Clay (fire). Common occurrence associated with coal beds in 14 counties in southwest part of State; mined in Clay County, at Brazil; Dubois County, Huntingburg; Vermilion County, West Montezuma; and in many other places.

Clay (kaolin). Greene County, occurs near Newark; Lawrence County, has been mined near Huron, and 2½ miles west of Shoals; Martin County, large deposit near Indian Springs Hotel; occurs at other places in Lawrence and Martin counties.

Clay (pottery). Productive localities: Clay County, Brazil and Center Point; Dubois County, Huntingburg; Owen County, high-grade, pinkish red 1¼ miles southwest of Freedom; Parke County, at Bloomingdale; Spencer County, at Lincoln City; Wayne County, alluvial deposits along Whitewater River. Slip clay mined at Elkhart, Elkhart County. Good quality clay, not mined at present, occurs at following places: Clark County, formerly mined near Port Fulton; Daviess County, near Washington, Cannelburg, Montgomery, and elsewhere; Fountain County, superior quality along bottoms of Coal Creek; also found near Shawnee Creek; Green County, good grade one-fourth mile east of Cincinnati and near Mineral City, was mined at Owensburg; Jefferson County, southeast of Dupont; Knox County, Enterprise mine near Bicknell; Martin County, Burns City pike, Little Boggs Creek, and elsewhere; Miami County, fine deposit on Weasaw Creek near Denver; Owen County, occurs in vicinity of Cataract, was mined at Spencer; Putnam County, superior quality near Cloverdale; Sullivan County, was mined at Pleasantville; Switzerland County, was mined at Vevay; Vanderburg County, was mined at Inglefield; Vermilion County, near Hillsdale; Vigo County, at Coal Bluff and elsewhere; Warrick County, in vicinity of Folsomville.

Coal (bituminous). Indiana ranked seventh in United States in 1912, producing over 15,000,000 tons. Coal area about 6,500 square miles in 26 different counties in southwestern part of State; 8 workable beds 3 to 10 feet thick. Produced commercially in following 19 counties: Clay, Daviess, Dubois, Fountain, Gibson, Greene, Knox, Martin, Owen, Parke, Perry, Pike, Spencer, Sullivan, Vanderburg, Vermilion, Vigo, Warren, and Warrick. "Brazil Black," peculiar to northeastern part of Clay County, has special value as furnace fuel; bed approaching exhaustion.

Dolomite. Cass County, quarried at Kenneth for flux. The Niagara limestone quarried along Wabash River is all dolomite.

Diamond. Found in panning gravels of glacial drift in Brown and Morgan counties; largest stone weighed 2.28 metric carats.

Flagstone. Decatur County, large quantities quarried at Greensburg and St. Paul; Franklin County, at Laurel; several quarries; Orange County, near Paoli; Putnam County, large quantity quarried at Putnamville; Wabash County, Wabash and vicinity; other localities for local use.

Gold (placer). Occurs very sparingly in glacial drift; washed from sands and gravel along streams in Brown and Morgan counties in small quantity; few flakes found in other counties.

Grindstone and scythestones. Have been quarried in Harrison County at Leavenworth; Lawrence County, at Huron; Warren County, at Redwood Creek. *See also* Oilstones and Whetstones.

Halite (common salt). In most deep borings or wells more or less salt water is found; not utilized. Salt was made from brines on small scale years ago in Harrison County, at Glen Fort salt works.

Hematite (red iron ore). Greene County, along Ore Branch, Richland Creek, and vicinity of Cincinnati; Lawrence County, sec. 28, T. 5 N., R. 2 W.; Martin County, south of Shoals; not used.

Kaolin (indianaite). Lawrence County, best known deposit at Huron; also found in Martin and Owen counties; has been mined.

Limestone (building). Quarried in Adams County, at Decatur and Linn Grove; Bartholomew County, Elizabethtown and Hartsville; Crawford County, Marengo and Milltown; Decatur County, Harris City, Letts, New Point, and St. Paul; Delaware County, Yorktown; Franklin County, Laurel; Grant County, small quantity quarried at Marion; Howard County, Kokomo; Huntington County, Huntington; Jennings County, Queensville and Scipio; Lawrence County, Bedford, Buff Ridge, and Wallner; Monroe County, Bloomington, Clear Creek, and Ellettsville; Shelby County, small quantity quarried at Waldron; Vanderburg County, at Evansville. Laurel limestone (Niagaran) quarried from extensive beds in Decatur County, at New Point, St. Paul, and Westport; Franklin County, Laurel; Ripley County, near Osgood; Wabash County, similar stone quarried near Wabash. Oolitic limestone, principal quarries: Harrison County, Corydon; Lawrence County, Bedford, Dark Hollow, and Oolitic; Monroe County, Bloomington, Ellettsville, Sanders, and Stinesville; Owen County, near Romona.

Limestone (crushed stone). Grant County, crushed at Marion and near Roseburg; Wabash County, on river bluff, near Wabash.

Limestone (flux). Quarried in Cass County, at Trimmer; Franklin County, Laurel; Lake County, Indiana Harbor; Lawrence County, Bedford; Monroe County, Bloomington and Ellettsville.

Limestone (lime). Has been or is burned in Carroll County, at Delphi; Cass County, Keesport; Clark County, near Utica; Crawford County, Milltown; Franklin County, near Laurel; Huntington County, Huntington; Jay County, Portland; Lawrence County, Mitchell; Madison County, near Ingalls; Ripley County, near Napoleon; Washington County, Salem.

Limestone (road metal). Quarried in Adams County, at Decatur, Geneva, and Lenn Grove; Blackford County, Montpelier; Carroll County, near Delphi; Cass County, Trimmer; Clark County, Jeffersonville and Sellersburg; Decatur County, small quantity quarried at Clarksburg; Delaware County, Muncie and Yorktown; Floyd County, Edwardsville; Fountain County, Davis Township; Franklin County, Brookville, Derbyshire Falls, and Laurel; Grant County, Liberty Township (Fairmount); Hamilton County, small quarries southwest of Fishersville; Harrison County, Corydon; Howard County, Kokomo; Huntington County, Huntington and Warren; Jasper County, Rensselaer; Jay County, Portland; Jennings County, North Vernon and Queensville; Lawrence County, 2 miles northeast of Mitchell, Williams, and elsewhere; Madison County, west part of Alexandria; Montgomery County, Waveland; Newton County, in vicinity of Kentland; Owen County, Spencer; Putnam County, Cloverdale and Greencastle; Pulaski County, Francesville; Randolph County, Farmland and near Ridgeville; Ripley County, Nolton; Rush County, New Salem; Shelby County, Waldron; Vanderburgh County, Inglefield, Evansville, and Howell; Wabash County, Wabash; Wells County, abundant in central part; White County, quarried at Bluffton, near Monon.

Limestone ("rock wool"). Madison County, upper layers Niagara limestone used at Alexandria for mineral or "rock wool" by melting and blowing into threads.

Limonite. *See* Brown iron ore.

Marl. Calcareous marl in glacial lakes in Elkhart, Fulton, Kosciusko, Lagrange, Lake, Marshall, Noble, St. Joseph, Starke, Steuben, and Whitley counties; minor deposits in Cass, Clinton, Laporte, Miami, Randolph, Vermilion, and White counties; largest marl bed is in Lake Wasassee, 1,700 acres, and thickest is 45 feet in Turkey Lake, Lagrange County.

Mineral paint. *See* Ocher.

Natural gas. There were 2,633 producing wells at close of 1911 in the following counties: Adams, Bartholomew, Blackford, Daviess, Decatur, Delaware, Grant, Hamilton, Hancock, Henry, Howard, Jay, Madison, Miami, Marion, Martin, Pike, Randolph, Ripley, Rush, Shelby, Spencer, Sullivan, Tipton, and Wayne.

Niter. Crawford and Harrison counties, occurs in caves, not mined.

Ocher (mineral paint). Dearborn County, deposits near Dillsboro; Dubois County, excellent quality has been mined near Ferdinand; Greene County, occurs near Washington; Martin County, has been extensively worked 1 mile west of Dover Hill; Miami County, in several places near Denver and in large quantities in vicinity of Chili; Vigo County, has been mined in Pierson Township.

Oilstones. Orange County, produced at Bonds, French Lick, and Orleans.

Peat. Peat bogs in Allen, Dekalb, Elkhart, Fulton, Jasper, Kosciusko, Lagrange, Lake, Laporte, Marshall, Miami, Newton, Noble, Porter, Pulaski, St. Joseph, Starke, Steuben, Wabash, White, and Whitley counties. Plant operating at Lakeville, St. Joseph County, makes fertilizer filler and briquets.

Petroleum. Production in 1911 was 1,695,289 barrels. Producing wells in the following counties: Adams, Blackford, Delaware, Gibson, Grant, Greene, Hamilton, Huntington, Jay, Perry, Pike, Randolph, Sullivan, Vigo, and Wells.

Pyrite. Knox County, has been mined at Bicknell; Parke County, Coxville; Vigo County, mined with coal at Terre Haute and Macksville.

Road metal. *See* Limestone (road metal).

Salt. *See* Halite.

Sand (building). Dug in Allen County, at Fort Wayne; Clark County, Jeffersonville and near New Albany; Clay County, Brazil; Daviess County, Washington; Floyd County, New Albany; Fountain County, Attica, Covington, and Silverwood; Hancock County, near Mohawk; Jefferson County, Madison; Lake County, Liverpool and Miller; Laporte County, Michigan City; Marion County, Indianapolis; Parke County, Montezuma; Porter County, Crisman and Willow Creek; Posey County, New Harmony; Randolph County, Farmland, Modoc, and Winchester; St. Joseph County, Mishawaka and South Bend; Sullivan County, Merom; Tippecanoe County, Lafayette; Vanderburgh County, Evansville; Vermilion County, Clinton; Vigo County, Terre Haute; Warren County, Kickapoo; Wells County, Liberty Center.

Sand (glass). Friable sandstone is quarried and crushed in Martin County, Loogootee; Parke County, at Coxville; White County, near Wolcott. Occurs in Blackford County, Montpelier; Floyd County, New Albany; Fountain County, near Hillsboro; Greene County, Johnson; Hamilton County, Lapel; Harrison County, Depauw; Madison County, bed has been quarried near Pendleton.

Sand (molding). Dug in Clark County, at Jeffersonville and near New Albany; Clay County, Aurora and Brazil; Jackson County, Brownstown and Seymour; Laporte County, Michigan City; Marion County, Indianapolis; Martin County, Loogootee; Morgan County, Centerton; Parke County, Coxville; Porter County, Crocker, McCool, and 4 miles southeast of Valparaiso; Spencer County, Rockport; St. Joseph County, South Bend; Wayne County, Fort Wayne.

Sand and gravel. Very abundant in many counties on bluffs and flood plains of streams.

Sandstone (building). Quarried in Clay County, at Brazil; Fountain County, at Riverside and Independence; Orange County, at West Baden and Paoli; Parke County, Coxville; Perry County, at Cannelton; Putnam County, near Raccoon and Bainbridge; Spencer County, at Rockport; Vermilion County, at Worthy. Occurs in Dubois County, at St. Anthony; Parke County, at Judson and elsewhere; Warren County, at Green Hill, Williamsport, and elsewhere.

Sapphire. Morgan County, bronze-colored sapphires are found in small number in gold placers.

Siderite. Fountain County, reported as occurring on Coal Creek and Wabash River; Martin County, south of Shoals near Coal Hollow; Monroe County, Indian Creek township; Putnam County, formerly mined at Eaglesfield; Scott County, lean manganiferous ores in Vienna and Finley townships; Vermilion County, Browntown Branch and Big Vermilion River; Vigo County, Terre Haute and Brouillets Creek; about 3,000 acres in Cass, Jasper, Starke, and White counties in beds 1 to 3 feet thick.

Tripoli (polishing powder). Dubois County, has been extensively worked near Ferdinand; Jackson County, deposits near Mooney; Lawrence County, Bedford; Sullivan County, near Merom; Washington County, near Bartle. "Drift marl" found in quantity in Clay County, near Carbon and Rushville; Owen County, near Gosport; Porter County, at Boone Grove.

Whetstones. Indiana ranks second among States in production of whetstones. Dubois, Martin, and Orange counties, Carboniferous sandstones (Pennsylvanian and Mississippian) afford abundant good grindstone "grit." Floyd County, have been quarried at Floyds Knobs; Orange County, have been quarried at Bonds, French Lick, Orleans, Paoli, and West Baden.

IOWA.

Brown iron ore (limonite). Allamakee County, Iron Hill; Clayton County, in lead and zinc regions; Dubuque County, in lead and zinc regions; Henry County, a lean ore on Skunk River; Jackson County, not in workable quantity; Webster County, in limited quantities.

Cement material. Shales and clays suitable for cement abundant in many parts of the State; calcareous constituent may be obtained from limestone, chalk, and marl, which see. Cement plants operating at Des Moines and Mason City.

Cerusite (lead carbonate). Allamakee County, at Lansing mine (abandoned); Dubuque County, found throughout Dubuque lead region but not in sufficient quantity to be valuable as an ore, except as mined with galena.

Chalcedony. Story County, near Ames, not used. In the geodes of southeastern Iowa.

Chalk. Associated with Cretaceous deposits of northwest Iowa; outcrop confined mainly to valley of Big Sioux River, between Sioux City and Hawarden; bed 30 to 50 feet thick.

Chert. Abundant in the Mississippian rocks in southeastern Iowa; also found associated with the Silurian rocks.

Clay (brick). Abundant in many counties; has been or is dug at one or more places in nearly every county in the State.

Clay (fire). Blackhawk County, has been used at Waterloo; Hardin County, Eldora; Montgomery County, Red Oak. Material suitable for refractory wares occurs in Clay, Des Moines, Henry, Jefferson, Polk, Van Buren, and Wapello counties.

Clay (gumbo). Cedar County, abundant; Decatur County, has been burned at Davis City; Monroe County, Selection; Pottawattamie County, on flood plains; used for railroad ballast.

Clay (pottery). Delaware County, has been dug and used in Colesburg; Des Moines County, near Parrish; Lee County, Donaldson; Mahaska County, 3 miles north of Eddyville, black ware only made; Montgomery County, Red Oak; Muscatine County, Fairport, mined and shipped; Polk County, Pennsylvanian ("Coal Measures") clay of Des Moines group, used for coarser grades of pottery; Van Buren County, Vernon; Webster County, Fort Dodge; Wapello County, Ottumwa. Occurs, but not used: Johnson County, thin seams near Iowa City; Monroe County, has been mined near Attica; Woodbury County, extensive deposits in lower part of the Benton or upper part of the Dakota at Sioux City.

Coal (bituminous). Coal-bearing formations occupy area of about 20,000 square miles in central and southern part of State; thin beds, noncoking. Mined in 21 counties as follows: Adams, Appanoose, Boone, Dallas, Greene, Guthrie, Jasper, Jefferson, Keokuk, Lucas, Mahaska, Marion, Monroe, Page, Polk, Taylor, Van Buren, Wapello, Warren, Wayne, and Webster.

Dolomite. Quarried extensively in Dubuque, Jackson, and other counties. Fine crystals in cavities: Lee County, Keokuk; Webster County, near Fort Dodge. It is prevalent in the Paleozoic rocks of the State.

Galena. Allamakee County, mined at New Galena; Clayton County, mined near Guttenberg and Buena Vista; Dubuque County, the important lead ore of Dubuque region.

Geodes. Lee County, abundant around Keokuk; sold for museum specimens.

Gold (placer). In drift in small quantities in Des Moines, Fayette, Keokuk, and Lee counties; no importance.

Granite. Bowlders in drift in several counties; locally used.

Gravel. Abundant in glacial deposits and river terraces. Used for road metal in Buchanan, Ida, Palo Alto, Pocahontas, Sac, Scott, and other counties; Polk County, dug for ballast along Fourmile Creek.

Gypsum. Extensive deposits quarried in Appanoose County, at Centerville; Webster County, Fort Dodge.

Hematite. Allamakee County, principal ore body at Iron Hill; widely distributed through shales and sandstones of the Pennsylvanian ("Coal Measures"); Jasper County, has been mined near Monroe for manufacture of metallic paints.

Lead minerals. *See* Cerusite and Galena.

Limestone (building, crushed stone). Quarried at one or more places in more than half the counties in the State.

Limestone (lime). Has been burned at several places in Benton, Blackhawk, Bremer, Cedar, Cerro Gordo, Clayton, Clinton, Davis, Des Moines, Henry, Humboldt, Jackson, Johnson, Linn, Mills, Mitchell, Monroe, Montgomery, Plymouth, Scott, Union, and other counties.

Limonite. *See* Brown iron ore.

Lithographic stone. Floyd County, occurs in Devonian; Mitchell County, southwest of Osage.

Marble. Not at present quarried in State. Floyd County, at Charles City, fossiliferous marbles were formerly used for mantels and table tops; Van Buren County, occurs at Chequest Creek, known to the trade as Chequest marble, white. The Bonaparte (gray) marble of the trade occurs near Bonaparte.

Marcasite. Des Moines County, abundant in Pennsylvanian ("Coal Measures") rocks; not mined.

Marl. Calcareous marl occurs in many small lakes in north-central part of State; no beds of importance yet discovered.

Mineral paint. *See* Hematite, Ocher, and Shale.

Natural gas. Small quantities in glacial drift. Dallas County, wells 100-115 feet deep produced small quantity of gas for several years; used for light and heat, few homes. Guthrie County, shallow wells near Bagley had several pounds' pressure; shut in, not used. Louisa County, wells about 100 feet deep near Letts and Wapello; gas from 4 wells has been used in owners' houses. Muscatine County, small showings of gas in shallow wells in southern part of county, not used.

Ocher (mineral paint). Allamakee County, deposits at Iron Hill and various points along Paint Creek; Jasper County, has been quarried at Fairview Township; Keokuk County, undeveloped deposit near Hayesville; Monroe County, deposits near Hamilton; Webster County, mined at Fort Dodge.

Petroleum. Nowhere discovered in commercial quantity, but rather widely disseminated as shown by traces in wells; found near Fort Madison, Lee County, in very small quantity.

Pyrite. Clayton County, associated with galena and sphalerite in lead-zinc mines; Dubuque County, in lead mines of Dubuque.

Quartz. Widely distributed; crystals in geodes near Keokuk, Lee County, and in mines of Des Moines County, exceptionally fine; sought for museum specimens.

Quartzite. Lyon County, valuable for building purposes, not utilized.

Road metal. Dallas County, gravel beds at Redfield and Van Meter worked extensively for railroad ballast; Dubuque County, dolomite quarried at Dubuque for macadam; Johnson County, stone crushed north of Coralville for railroad ballast, products of Iowa City also used; Madison County, large quantities of limestone crushed for use in Des Moines; Montgomery County, limestone in this county would make excellent macadam; Polk County, gravel beds at Des Moines extensively worked for railroad ballast.

Sand (building). Large supply of good building sand along streams and in sand hills of Benton, Cedar, and Jackson counties; at various points along river in Humboldt County. Pits are worked in the following counties: Appanoose, Audubon, Blackhawk, Buena Vista, Butler, Cherokee, Clinton, Des Moines, Dickinson, Dubuque, Emmet, Fayette, Grundy, Hardin, Howard, Ida, Johnson, Jones, Kossuth, Lee, Linn, Lyon, Mahaska, Marion, Montgomery, O'Brien, Osceola, Palo Alto, Plymouth, Polk, Sac, Scott, Sioux, Story, Van Buren, Wapello, Webster, Woodbury, and Wright.

Sand (glass). Allamakee County, glass sand is abundant in St. Peter sandstone, but is not used; Clayton County, pits worked near Clayton; Johnson County, River Junction; Linn County, Cedar Rapids.

Sand (molding). Dug in Appanoose County, at Centerville; Audubon County, Kimballton; Cherokee County, Cherokee; Linn County, Cedar Rapids; Lyon County, Doon; Marshall County, Marshalltown; Polk County, Des Moines and Valley Junction.

Sand and gravel. Large quantities in stream and drift deposits of Des Moines, Franklin, Lee, Marshall, Muscatine, and other counties.

Sandstone. Sandstone has been quarried in Allamakee County; Clay County, at Garnavillo; Dallas County, Redfield; Davis County, Carbon, local use; Des Moines County, Danville; Dubuque County, Spechts Ferry; Guthrie County, quarried at many points for local use; Hardin County, Eldora and near Steamboat Rock; Jackson County, several small quarries; Jasper County, near Lynnville; Jefferson County, at many points; Jones County, Olin; Lee County, very small quantity quarried at Franklin Township; Marion County, large supply at Red Rock quarry; Muscatine County, along Mississippi River from Scott County to 3 miles west of Muscatine, also quarries on West Branch of Pine Creek in Montpelier Township; Polk County; Scott County, small quantity quarried at Buffalo; Webster County, Washington Township; Woodbury County, near Sioux City.

Shale. Webster County, ground for use as pigments at Fort Dodge.

Silver. Dubuque County, in minute quantities in lead ore at Dubuque; not recovered.

Smithsonite. Clayton County, in lead mines near Buena Vista and Guttenberg; Dubuque County, a common zinc ore at Dubuque mines.

Sphalerite. Allamakee County, mined 5 miles west of Lansing; Clayton County, associated with galena in flat crevices and fissures in galena limestone; Dubuque County, mined near Dubuque.

Tripoli (polishing powder). Des Moines County, abundant, not used.

Zinc ore. *See* Smithsonite and Sphalerite.

KANSAS.

Abrasive. *See* Pumice.

Calamine (zinc silicate). Cherokee County, secondary mineral of zinc ore mined at Galena.

Cement materials. Limestone and shale used for Portland cement in Allen County, at Iola and Concreto; Anderson County, at Mildred; Bourbon County, Fort Scott; Ellis County, Yocemento; Montgomery County, Independence and Le Hunt; Wilson County, Neodesha and Fredonia; Wyandotte County, Bonner Springs. In great abundance generally in eastern two-thirds of State.

Cerusite (lead carbonate, "dry bone"). Cherokee County, secondary mineral of lead ores mined at Galena.

Clay (brick). Dug in the following counties: Allen, Atchison, Bourbon, Chautauqua, Cherokee, Clay, Cloud, Crawford, Douglas, Elk, Franklin, Hamilton, Labette, Leavenworth, Linn, McPherson, Marshall, Miami, Montgomery, Nemaha, Neosho, Phillips, Saline, Shawnee, Wilson, and Wyandotte.

Clay (fire). Fire clay in Pennsylvanian ("Coal Measures") rocks, in Bourbon County, at Fort Scott, under the coal; Douglas County, Lawrence; Leavenworth County, near Leavenworth; Mill Creek; in all the eastern counties as far west as Manhattan; not pure.

Coal (bituminous). About 20 workable beds, from a few inches to 5 feet thick; essentially steam coals, mined in Atchison County, near Atchison; Cherokee County, Cherokee coal, 18 inches to 5 feet thick, mined at Scammon, excellent quality; Crawford County, Frontenac, Pittsburg, and elsewhere; Franklin County, near Ransomville; Leavenworth County, Leavenworth; Osage County, Osage seam 20–22 inches, along Santa Fe Railway; and many other places. Southeastern part of the State, south of the Kansas River and east of the Shawnee, has workable beds in nearly every county, and beds crop out in Allen, Bourbon, Brown, Coffey, Doniphan, Douglas, Franklin, Greenwood, Jackson, Jefferson, Miami, Nemaha, Neosho, Osage, Shawnee, Wabaunsee, Woodson counties.

Galena. Cherokee County, most abundant lead ore at Badger-Peacock, Galena, and Lawton districts.

Gypsum. Gypsite (gypsum earth), found in low swampy ground in central Kansas forms basis of greater portion of plaster manufacture; mined in Barber County, at Kline; Butler County; Clay County, at Longford. Rock gypsum, mined in Barber and Comanche counties, in Medicine Lodge area; Dickinson County, at Hope; Marshall County, Blue Rapids; Saline County, near Gypsum City. In comparative abundance at numerous places in the Permian rocks of Kansas; in smaller quantities along Smoky River, Ellsworth County, and McPherson County; Tertiary formations in southwestern part of Meade County and Seward County, often in fine crystals. Nearly all gypsite beds in Kansas are exhausted.

Halite. *See* Salt.

Hydrozincite. Cherokee County, with calamine and smithsonite, Galena district.

Lead. *See* Cerusite and Galena.

Lignite (brown coal). Extensive beds in the Cretaceous strata, and sparingly in Tertiary, Smoky Hill Valley; beds of good brown coal over large part of western Kansas, range from 1 to 3 feet thick; few beds in Dakota (Cretaceous) strata, always of inferior quality; most important seam 10 to 36 inches thick, is traceable for 170 miles from the northern boundary southwestward across the State, and is found in Barton, Cloud, Ellsworth, Lincoln, McPherson, Mitchell, Ottawa, Republic, Rice, Saline, Washington, and perhaps other adjoining counties.

Limestone (building). Quarried in following places: Atchison County, Atchison; Bourbon County, Fort Scott; Brown County, Hiawatha; Butler County, Augusta and Eldorado; Chase County, Cottonwood Falls; Chautauqua County, Sedan; Cowley County, Silverdale and Winfield; Douglas County, near Lawrence; Franklin County, Ottawa; Greenwood County, Madison; Jackson County, Delia; Jewell County, Randall and near Formosa; Johnson County, Olathe; Labette County, one-half mile south of Parsons; Leavenworth County, Leavenworth; Lyon County, Admire, and near Americus and Emporia; Marion County, Florence and Marion; Marshall County, Irving, Frankfort, and Marysville; Miami County, Paola; Neosho County, Chanute and Erie; Ness County, Bazine; Phillips County, Logan Township; Pottawatomie County, Emmett and Wamego; Riley County, Manhattan and vicinity; Rush County, Alexander; Russell County, Russell; Shawnee County, Topeka; Sumner County, Caldwell; Wabaunsee County, Alma; and Wyandotte County, Quindaro.

Limestone (crushed stone). Atchison County, Atchison; Brown County, Fairview and Hiawatha; Butler County, Augusta and Eldorado; Chase County, Cottonwood Falls; Chautauqua County, Sedan; Cowley County, Silverdale and Winfield; Douglas County, Lawrence; Elk County, Moline; Franklin County, Ottawa and Wellsville; Greenwood County, Hilltop and Madison; Jackson County, Delia; Johnson County, Olathe; Labette County, one-half mile south of Parsons; Leavenworth County, Leavenworth; Lyon County, near Allen and Americus; Marion County, Florence; Marshall County, Beattie, Irving, Frankfort, and elsewhere; Miami County, Paola; Morris County, Dwight; Neosho County, Chanute and Erie; Pottawatomie County, Emmett; Riley County, Manhattan; Russell County, Russell; Saline County, Salina; Shawnee County, Topeka; Wyandotte County, Loring, Quindaro, and vicinity.

Limestone (lime). Burned for lime: Bourbon County, at Fort Scott; Chautauqua County, at Sedan; Elk County, at Moline; Shawnee County, at Topeka.

Limestone (hydraulic, water lime, cement rock). Bourbon County, magnesian limestone occurs at Fort Scott, to some extent hydraulic. Manufactured at Fort Scott.

Marcasite. Cherokee County, abundantly associated with lead and zinc ores at some mines in Galena district. Requires roasting and electric treatment to remove from ore.

Natural gas. Wells in Allen County, Iola, La Harpe, Moran, Savonburg, and Humboldt; Chautauqua County, Peru, Sedan, and many points in southern half of county; Franklin County, Rantoul; Johnson County, Spring Hill; Linn County, Pleasanton, local use; Miami County, Paola and Osawatomie; Montgomery County, Cherrydale, Coffeyville, Independence, Caney, Havana, Jefferson, and Dearing; Neosho County, Chanute, Erie, and Thayer; Wilson County, Altoona, Benedict, Buffalo, Fredonia, Neodesha, New Albany, and Vilas; Wyandotte County, Bonner Springs and Kansas City.

Petroleum. Producing wells in Allen County, vicinity of Moran and Humboldt; Chautauqua County, Sedan, and southern part; Miami County, high-grade oil, Paola; Montgomery County, Coffeyville, Wayside, and elsewhere in Bolton field; Neosho County, Chanute; Wilson County, in vicinity of Benedict, Neodesha, and Buffalo; Woodson County, vicinity of Toronto. Occurs at numerous other places in State. About 1,800 producing wells in 1910.

Pumice. Dug in Gove County, Quinter; Meade County, Meade; Phillips County, Woodruff; and has been found in many other places.

Pyrite. Cherokee County, associated with lead and zinc ores in Galena district; also abundant in many coal mines of the State.

Salt (brine). Brines obtained from Cherokee and other shales throughout the oil and gas fields. Manufacturers of evaporated salt in Ellsworth County, Ellsworth; Reno County, Hutchinson; and Rice County, Sterling.

Salt (rock). Mined in Ellsworth County, at Ellsworth and Kanopolis; Harper County, Anthony; Kingman County, Kingman; Rice County, Sterling and Lyons.

Sand (building). Dug in Douglas County, at Lawrence; Leavenworth County, at Leavenworth; Reno County, at Hutchinson; Sedgwick County, at Wichita; Shawnee County, at Topeka; Wyandotte County, at Armourdale and Kansas City.

Sandstone. Quarried in Bourbon County, at Fort Scott, Hiattville, and Redfield; Chautauqua County, Chautauqua Springs; Elk County, Howard; Labette County, Parsons; Linn County, Pleasanton; Montgomery County, Independence; Pawnee County, Larned; Pottawatomie County, Onaga; Woodson County, Yates Center.

Siderite (spathic iron ore). Bourbon County, occurs in Pennsylvanian ("Coal Measures") rocks on Marais des Cygnes, near Fort Scott; also on the Neosho and many other streams, interstratified with beds of good coal. Not sufficiently abundant for use.

Smithsonite (zinc carbonate). Cherokee County, mined in Galena district.

Sphalerite (zinc blende). Cherokee County, principal ore of zinc in Badger-Peacock, Galena, and Lawton districts.

Zinc. *See* Calamine, Hydrozincite, Smithsonite, and Sphalerite.

KENTUCKY.

Asphalt. Bituminous sandstones are found in the following places: Breckinridge County, quarried 2 miles southwest of Garfield and 2 miles southeast of Harned; Carter County, prospected at Soldier; Edmondson County, small tar springs and many deposits of bituminous sandstone in Bee Spring region, quarried at Pittsburg Landing on Green River; Grayson County, prospect 3 miles south and 9 miles north of Leitchfield, large abandoned quarry at Tar Hill, 9 miles northeast of Leitchfield; Logan County, quarry 5 and 6 miles northeast of Russellville; Rowan County, prospected near Morehead; Warren County, two quarries at Youngs Ferry.

Barite. Anderson County, at Lawrenceburg; Bourbon County, has been mined at Millersburg and near Paris; Boyle County, mined near Danville; Caldwell County, was mined at Fredonia, and shipped; Fayette County, mined and shipped from near Lexington; Franklin County, gangue mineral of Clerk vein near Kissinger; Gerrard County, 4 miles west of Lancaster; Harrison County, in Ordovician limestone, 3 miles southeast of Cynthiana, at Lair Station and vicinity; Henry County, Lockport, and other points, mined and shipped; Jessamine County, 1 mile northeast of Ambrose; Mercer County, was mined near Harrodsburg; Owen County, Gratz mine and other points; Scott County, gangue mineral of Johnson vein 1½ miles from Duvall Station and other points; Woodford County, with galena and sphalerite at Shyrock Ferry, Shropshire, Prewitt, and other prospects; at points in Garrard, Jessamine, Lincoln, Madison, and Russell counties.

Brown iron ore (limonite, brown ore). Bath County, mined at Preston ore banks; occurs in Red River iron region, between Licking and Kentucky rivers, ores at base of Pennsylvanian series ("Coal Measures"); Hanging Rock region, embracing whole or parts of Boyd, Carter, Greenup, Johnson, and Lawrence counties in northeastern part of State. Iron made from these ores noted for its excellence for castings. In abundance from Ohio River southward to southern part of Carter County; Cumberland River iron region, embracing whole or parts of Caldwell, Crittenden, Livingston, Lyon, and Trigg counties in western part of State; occurs in clay and chert above Mississippian limestones, irregular shape and uncertain extent, but aggregate of ore immense; most extensive deposits are between the Tennessee and Cumberland rivers, and of excellent quality. Nolin district, in Butler, Edmonson, Grayson, Muhlenberg, and Ohio counties; ores occur near base of the Pennsylvanian rocks ("Coal Measures"). "Oriskany" ore on north slope of Pine Mountain, Bell County, has been mined.

Calcite. Fayette County, in vicinity of Morton's Mill, and 6 miles north of Lexington; Livingston County, Spees mine, was mined; Mercer County, is mined and milled at Chinn mine on Kentucky River at mouth of Shawnee Run; Owen County, gangue mineral in Gratz mine; Woodford County, with sphalerite at Shyrock Ferry. Most abundant mineral associated with fluorite in western Kentucky.

Cement material (Portland). Jefferson County, only plant in State in 1912 at Kosmosdale; oolitic limestone from Meade County used. Limestones suitable for Portland cement are abundant in north-central and western part of State. Cement plants are proposed in Campbell County, at Mentor; Kenton County, at Ludlow; Powell County, at Stanton; Rockcastle County, Pine Hill; and a plant was being built in January, 1913, near Livingston, Rockcastle County. Large quantity of pure clay suitable for Portland cement in counties of the Jacksons Purchase region in west Kentucky, west of Tennessee River.

Cement rock (natural). Jefferson County, cement rock first discovered in Central States in digging canal at Louisville. Quarried for natural cement. Similar materials in Lewis and other counties along western border of eastern coal field.

Clay (brick). Widely distributed; used in nearly all counties of the State.

Clay (fire). Flint and plastic clay in Boyd, Carter, Greenup, Lewis, Powell, Rockcastle, Rowan, Wolfe, and other counties of east Kentucky. Siliceous refractory clays in counties west of Tennessee River and also in Crittenden and Livingston counties.

Clay (pottery). Ballard County, thin beds of white plastic clay from Laketown southward and in a few places in eastern part of county; Calloway County, at Potterton; Fulton County, large quantity in bluffs at Hickman, and southward to Tennessee line; Graves County, white, ball, and sagger clay mined at Clay Switch; Hart County, near Bonnieville; Hickman County, pottery clay near Columbus; Madison County, Waco and Bybeetown; McCracken County, in eastern and middle portions and 5 miles south of Paducah; Marshall County, near Scales, west of Benton, and near Palma; was mined at Scale and Hardin.

Coal (bituminous). Pennsylvanian ("Coal Measures") rocks occupy the eastern and western parts of the State. Twelve or more beds which range from 2 to 8 feet in thickness are identified in the eastern field. Most coals hard bituminous, semiblock, excellent for steam and domestic purposes. High-grade coking coals in Big Sandy Valley. The coal-producing counties of eastern Kentucky are: Bell, Boyd, Breathitt, Carter, Clay, Elliott, Floyd, Greenup, Harlan, Jackson, Johnson, Knott, Knox, Laurel, Lawrence, Lee, Leslie, Letcher, Magoffin, Martin, Morgan, Owsley, Perry, Pike, Pulaski, Rockcastle, Wayne, Whitley, and Wolfe. The coal-producing counties of western Kentucky are: Butler, Christian, Crittenden, Daviess, Edmonson, Grayson, Hancock, Henderson, Hopkins, McLean, Muhlenberg, Ohio, Union, Warren, and Webster.

Dolomite. Ordovician, excellent building material, found along Kentucky River in Clark, Fayette, Franklin, Jessamine, and Woodford counties; a buff and cream colored dolomite, convenient to transportation; "Corniferous" limestone in Bullitt and Nelson counties, of excellent quality and in vast quantities; quarried to some extent.

Fluorspar. Caldwell County, near Princeton and other points; Crittenden County, at Crayne, Marion, and Mexico; Fayette County, in Ordovician limestone in vicinity of Morton's Mill; Jessamine County, south of Ambrose on north side of McKenna branch; Livingston County, Salem and other points; Mercer County, with calcite and barite around bend of Kentucky River and Two Chimneys and Fantail mines; Trigg County, at Gracey; Woodford County, at Faircloths Ferry, below Brooklyn and elsewhere, and was mined at Withrow vein near Spring Station.

Galena. Bourbon County, prospects at Paris and vicinity; Caldwell and Crittenden counties, with fluorspar at Asbridge, Glendale, Tabor, and other mines; Fayette County, Russell Cave and elsewhere; Franklin County, large masses at Kissinger; Harrison County, was prospected near Cynthiana and Lair Station; Livingston County, Evening Star mine; Owen County, Gratz mine; Scott County, Johnson vein about 1½ miles from Duvall Station; Woodford County, with barite at Withrow vein near Spring Station. Other points in central Kentucky barytes district.

Garnet (pyrope). Elliott County, in peridotite dike on Ison Creek.

Gravel. Ballard County, mined at Wyckliffe; Hickman County, thick beds in bluffs around Columbus; McCracken County, Paducah; abundant in region west of Tennessee River along Ohio River and in regions bordering coal fields, from conglomerate sandstone. Abundant at a number of other points in the Jackson Purchase.

Hematite (red iron ore). Bath County, mined near Owingsville; Graves County, small quantity in gravel beds 2½ miles south of Hard Money; was mined in Fleming County; Marshall County, small quantity near Birmingham.

Lignite. Ballard County, Fort Jefferson bluff and near Blandville; Graves and Hickman counties.

Limestone. Widely distributed. Used in many counties. Quarried: Boyle County, at Danville and Perryville; Fayette County, Lexington; Jefferson County, Florida Heights, Louisville, and Tucker; Jessamine County, Nicholasville; Kenton County, Covington and Latonia; Pendleton County, Ivor and near Carntown; Warren County, Bowling Green and Hadley. Has been quarried: Barren County, near Glasgow Junction; Caldwell County, near Princeton and Leitchfield; Pulaski County, near Somerset; also in Grayson, Meade, Simpson, Todd, Wolfe, and other counties.

Limestone (flux). Quarried: Boyd County, at Ashland; Carter County, Lawton and Limestone; Kenton County, Covington; Rockcastle County, Burr; occurs at many other points.

Limestone (lime). Quarried: Christian County, at Hopkinsville; Hardin County, Elizabethtown; Meade County, near Battletown and Cedar Branch; Rockcastle County, Mount Vernon; Union County, Mississippian limestone was burned near Morganfield.

Limestone (oolitic). Large quarries in Warren County. The oolite outcrops around eastern and northern edge of western coal field and across from there to western edge of eastern coal field.

Lithographic stone. Most important quarry in United States at Bradensburg, Meade County. Found in Bath, Estill, Pulaski, Rowan, Warren, and Wayne counties.

Marble. Barren County, pink and yellow varieties quarried near Cave City; Warren County, near Bowling Green; also in Bath and Rowan counties.

Marl. Bullitt and Spencer county line, in Ordovician; Garrard, Lincoln, Madison, Marion, Nelson, and Washington counties, in Silurian shales. In the Chester group of the Mississippian series in many counties is a marly shale, containing 4 to 6 per cent of potash, 1 or 2 per cent of phosphoric acid, and 15 per cent of lime. Worked near Leitchfield, Grayson County.

Mineral paint. *See* Ocher.

Natural gas. Barren County, small quantity near Glasgow; Boyd County, at Ashland and near Catlettsburg; Breckenridge County, number of wells in Mississippian limestone at Cloverport; excellent illuminant gas, also domestic fuel to town; Clay County, near Manchester; Estill County, near Irvine; Hardin County, at Elizabethtown; Knox County, large flow was obtained from Big Injun sand near Barbourville; Lawrence County, in Berea sandstone in Horsford well; Logan County, near Diamond Springs; Martin County, large field near Eden; Meade County, most important gas district of western Kentucky, a number of wells in vicinity of Brandenburg and Rock Haven in Devonian shale; Menifee County, "Corniferous" limestone source of large supply of gas; wells on Gay, Mynhier, and other forms near Frenchburg; piped to Mount Sterling, Winchester, and Lexington. Morgan County, Caney sand at Caney, source of high-pressure gas; little development; also on Licking River, supplies West Liberty. Warren County, near Bowling Green, no economic value; Wayne County, large producing wells at Pisgah; Wolfe County, near Campton and near Hazel Green.

Ocher. Ballard County, yellow ocher was mined in the bluffs of creeks near Laketon and in ravine east of Wyckliffe; Calloway County, near Murray; Carlisle County, was mined near Laketon; Crittenden County, 5 miles southwest of Marion; McCracken County, mined 3 miles east of Paducah; Marshall County, on banks of Tennessee River at Highland Landing.

Onyx marble. Barren, Hart, and Edmonson counties, found in limestone caverns.

Petroleum. Oil-producing areas: Barren County, near Glasgow; Bath County; Breathitt County, Frozen Creek; Cumberland County, near Burkville; Estill County, near Irvine; Floyd County, Right Beaver, Salt Lick, and Middle creeks near Prestonburg; Knox County, vicinity of Barbourville; Lawrence County, Busseyville; Logan County, Diamond Springs; Menifee County; Morgan County, Caney and West Liberty; Ohio County, near Hartford; Rowan County, Triplet Creek; Wayne County, number of wells; Webster County, Lebree; Whitley County, near Williamsburg; Wolfe County, near Campton. Oil shows reported in Allen, Boyd, Breckenridge, Caldwell, Carroll, Carter, Christian, Clark, Clinton, Harrison, Hart, Jefferson, Johnson, Knott, Lawrence, McLean, Magoffin, Martin, Meade, Montgomery, Oldham, Pike, Pulaski, Rockcastle, Russell, and Warren counties.

Phosphate rock. Woodford County, mined at Midway; occurs in thin plates and finely comminuted débris from weathering of phosphatic limestone beds at the top of the Lexington limestone and base of the Winchester limestone (Ordovician).

Salt. Salt brines found in gas and oil wells in Breckenridge, Clay, Estill, Hancock, Henderson, Jefferson, Meade, Union, and other counties. May be utilized as source of salt.

Sand (building). Dug: Boyd County, at Ashland; Campbell County, Dayton; Jefferson County, Louisville and Shively; McCracken County, Paducah; Rockcastle County, Dudley and Withers; Warren County, Bowling Green.

Sand (glass). Dug: Calloway County, in hills bordering Beechy Creek; Carter County, Lawton; Hardin County, at Tip Top, 28 miles southwest of Louisville; Kenton County, Ludlow.

Sand (molding). Dug: Boyd County, at Ashland; Kenton County, Covington and Visalia; Warren County, Bowling Green.

Sandstone. Quarried: Bell County, at Pineville; Breckenridge County, near Garfield; Knox County, Barbourville; Logan County, near Russellville; Muhlenberg County, South Carrollton; Rockcastle County, Langford and Wilfie; Rowan County, Bluestone, Farmers, Freestone, and Morehead. Occurs in many other counties of the State.

Siderite. Boyd, Carter, and Greenup counties, original mineral of Hanging Rock iron ores; Butler, Edmonson, Grayson, Hart, and Muhlenberg counties, occurs in Nolin River district near base of the Pennsylvanian series ("Coal Measures"), largely undeveloped; Whitley County, near Cumberland Falls.

Silver. Crittenden County, recovered from lead concentrates separated from fluorspar.

Smithsonite (zinc carbonate). Crittenden County, mined and shipped from Old Jim, Brown, Hodge, Columbia, and other mines.

Sphalerite (zinc blende, blackjack). Crittenden County, mined at Old Jim and Columbia mines; Livingston County, Evening Star mine; occurs in many other mines, usually associated with fluorspar and galena, as accessory mineral in central Kentucky barytes district, and in veins in Lewis County.

Sulphur. Sulphur springs are common all over the State.

Tripoli. Fulton County, in gray silt in top of Hickman bluff and southward, and at several points in eastern parts of Calloway and Marshall counties; not used.

LOUISIANA.

Brown iron ore (brown hematite, limonite). In Tertiary sands in Bienville, Bossier, Caddo, Claiborne, Lincoln, and Union parishes; not used.

Clay (brick). Abundant throughout the State; dug in following parishes: Ascension, Assumption, Avoyelles, Caddo, Calcasieu, De Soto, East Baton Rouge, East Feliciana, Franklin, Grant, Iberia, Harvey, Lafourche, Lincoln, Livingston, Natchitoches, Ouachita, Pointe Coupee, Rapides, Richland, St. Landry, St. Martin, St. Mary, St. Tammany, Tangipahoa, Vermilion, Webster, and West Feliciana.

Clay (pottery). Numerous outcrops of very pure white clay called "chalk" in Caddo Parish, near Spring Ridge church, Chalk Hills, and elsewhere; Catahoula Parish, in north-central part of parish; La Salle Parish, has been mined at Rosefield; Natchitoches Parish, lignitic clay near Robeline; Rapides Parish, pure white potter's clay reported in "Grand Gulf" rocks near Lena; and Sabina Parish, 10 miles southeast of Fort Jesup.

Gravel (road metal). Extensive deposit in hills of south Rapides Parish; also in Catahoula, Claiborne, Grant, Sabine, St. Landry, Washington, and Winn parishes; largely used.

Gypsum. Bienville Parish, with limestone at Rayburns salt works; Calcasieu Parish, large quantity in sulphur deposits at Lake Charles; Caldwell Parish, selenitic clays 85 feet thick at Grand View, on Ouachita River; St. Landry Parish, at Pine Prairie.

Hematite. Occurs in Bienville, Grant, Natchitoches, Rapides, Red River, Sabine, Winn, and other parishes; not used.

Iron. *See* Brown iron ore and Hematite.

Lignite. Bienville Parish, occurs in eastern part; Caddo Parish, West Shreveport; Caldwell Parish, near Columbia; Claiborne Parish, near Homer; De Soto Parish, northwestern part; Sabine Parish, Coalkill Creek, 6 miles east of Fort Jesup.

Limestone (building). St. Landry Parish, small outcrops; good building stone.

Limestone (crushed stone). Winn Parish, produced at Winnfield.

Limestone (lime). Natchitoches Parish, was burned locally 5 miles from Natchitoches; Sabine Parish, Rocky Spring; St. Landry Parish, Pine Prairie, and on Bayou Chicot.

Limonite. *See* Brown iron ore.

Marl. Occurs in Catahoula Parish, at Sicily Islands; Claiborne Parish, in vicinity of Homer and Lisbon; Grant Parish, near Montgomery, "Zeuglodon marl" contains glauconite; Natchitoches Parish, phosphatic and greensand marl in bluff at Natchitoches, calcareous.

Natural gas. Caddo Parish, large production from Caddo field near Shreveport; Calcasieu Parish, considerable quantities at Welsh oil wells; De Soto Parish, abundant at Mansfield and Naborton; East Baton Rouge Parish, occurs in several gas pockets in well at Deerford; Grant Parish, in well at Colfax; Iberia Parish, abundance on Bayou Bouillon, 30 miles northeast of New Iberia; La Fourche Parish, small production; Sabine Parish, in salt spring near mouth of Bayou Negrett; St. Martin Parish, above oil in Anse-La-Butte field, and considerable quantity from "Natural Gas Spring," 2½ miles from Breaux Bridge; St. Mary Parish, Belle Isle; Terrebonne Parish, common occurrence in Quaternary areas.

Petroleum. Caddo Parish, Caddo field important producer; Calcasieu Parish, Vinton gushers in 1911, numerous wells 6 miles northeast of Jennings in Quaternary and Miocene beds, best lubricating oil in southern region in wells near Welsh; Cameron Parish, small quantity of oil from wells on Hackberry Islands; Iberia Parish, small quantity in wells at Bayou Bouillon 30 miles northeast of New Iberia; St. Landry Parish, Pine Prairie, gusher 1912; St. Martin Parish, in coarse shallow sands at Breaux Bridge, Anse-La-Butte district.

Salt (brine). Bienville Parish, Rayburn's salt works, and Kings; Lafayette Parish, salt brines in wells of Anse-La-Butte oil field, and other oil fields, and artesian boring for brine, T. 12 N., R. 5 W.; Natchitoches Parish, old salt works.

Salt (rock). Evangeline Parish, occurs at Pine Prairie, not mined; Iberia Parish, large quantities mined from shafts on Weeks and Avery Islands; North Bienville Parish, has been mined on Saline Bayou and about 8 miles from Bienville; Sabine Parish, has been mined near Coal Bluff and near mouth of Negrett Bayou. Occurs also at Belle Isle, and Jefferson's Island, but is not mined.

Sand (building). Dug: Caddo Parish, at Shreveport; St. Tammany Parish, Bayou Lacomb, and Covington; Webster Parish, Lanesville; West Baton Rouge Parish, Baton Rouge.

Sandstone. Catahoula Parish, small quarries in "Grand Gulf" sandstone near Harrisonburg; Sabine Parish, quarried on Bayou Toro, canal and railroad construction; Winn Parish, best in small exposure at Coochie Brake.

Sandstone (ballast). Iberia Parish, occurs in Iron Mine Run on Petite Anse; Rapides Parish, "Grand Gulf" sandstone quarried between Boyce and Lena.

Sulphur. Calcasieu Parish, obtained from wells in extensive deposit about 3 miles from town of Sulphur; sulphur and associated beds are some hundreds of feet thick; sulphur, associated with limestone above gypsum, melted by superheated water and pumped out by Frasch process.

MAINE.

Amethyst. Oxford County, gem crystals found on Deer Hill in town of Stow, and on Pleasant Mountain, in the town of Denmark.

Apatite. Androscoggin County, in transparent pink, purple, blue, and green crystals, at Apatite Hill, Wade, and Pulsifer quarries in town of Auburn, Berry quarry, town of Poland; Oxford County, at Hebron.

Argentite (silver glance). Hancock County, reported from Sullivan silver mine.

Arsenopyrite (arsenical pyrite). Franklin County, Titcombs Hill, Farmington; Hancock County, occurs in Blue Hill and Brooksville copper mines, and Sullivan silver mines, was prospected on Verona Island; Knox County, occurs at Owls Head, South Thomaston; Oxford County, occurs at Corinna, Greenwood, Rumford, and at Mount Rubellite in town of Hebron; Waldo County, occurs in veins in schist at Fort Point; York County, Bonds Mount and Newfield, and accompanying silver ores at Lebanon and Acton.

Beryl. *Aquamarine.*—Kennebec County, at Winslow with mica and fluorite in cassiterite vein; Oxford County, French Mountain, town of Albany; Dunton mine, town of Newry; Mount Mica, town of Paris, associated with corundum, town of Greenwood; Sugar Hill and Harndon Hill, town of Stoneham.

Golden beryl.—Oxford County, Edgecomb Mountain, town of Stoneham, and Speckled Mountain, town of Peru.

Cæsium beryl.—Androscoggin County, Berry quarry, town of Poland; Oxford County, town of Hebron; on Dudley farm, town of Buckfield.

Opaque varieties common in pegmatites, notably: Androscoggin County, Apatite Hill, town of Auburn; Hancock County, in cassiterite-bearing granite at Catharine Hill; Oxford County, Noyes mine, town of Greenwood.

Bornite (purple copper ore). Hancock County, has been mined in Ellsworth schist at Blue Hill; Washington County, Lubec lead mine and Pembroke copper prospects; not abundant.

Brown iron ore (bog iron ore). Lincoln County, occurs on Pemaquid Ledge; Oxford County, at Rumford; Piscataquis County, Dover, several deposits of large size; Somerset County, Skowhegan, several large deposits; York County, New Limerick and Newfield.

Brown iron ore (brown hematite, limonite). Aroostook County, occurs at Houlton and Linneus; Hancock County, most abundant oxidized mineral in Blue Hill and Brooksville district; Piscataquis County, has been mined at Katahdin mines; Washington County, has been mined at Trescott and at Lubec lead mine, at latter place trace of gold, some silver.

Cassiterite. Kennebec County, occurs in 1-inch vein at Winslow; Oxford County, occasional specimens at Mount Mica and Greenwood.

Cement material. Knox County, limestone near Rockland suitable for Portland cement.

Cerargyrite (silver chloride). Hancock County, reported from Sullivan silver mine.

Chalcocite (copper glance). Hancock County, sparingly on chalcopyrite at Blue Hill copper mines, at Douglas mine carries gold and silver.

Chalcopyrite (copper pyrites). Hancock County, important mineral of Blue Hill; has been mined at Douglas, Twin Lead, and other mines for gold and silver; Somerset County, has been mined at Robinson mine; Washington County, occurs in old mines at Cooper; has been mined at Cherryfield and Lubec lead mine for gold and silver, at Pembroke copper prospect.

Clay (brick). Knox County, deposits and brick works at Thomaston, South Thomaston, and Rockland. Dug: Androscoggin County, at Danville, Durham, Leeds Junction, and elsewhere; Aroostook County, Masardis and Presque Isle; Cumberland County, Brunswick, North Yarmouth, and Portland; Hancock County, East Sullivan, Ellsworth, Orland, and elsewhere; Kennebec County, Augusta, Waterville, and Winslow; Oxford County, East Bethel; Penobscot County. Bangor, Brewer, and Howland; Piscataquis County, Abbot Village and East Dover; Sagadahoc County, Bath, Topsham, and Woolwich; Somerset County, Madison; Washington County, Calais and Lubec; York County, Eliot, Kennebunk, Saco, and elsewhere.

Columbite. Androscoggin County, sparingly in pegmatite at Apatite Hill, town of Auburn; Cumberland County, town of Standish; Oxford County, Mount Mica, town of Paris; Sagadahoc County, Harndon Hill, town of Stoneham; Mount Ararat and Willes feldspar quarry, town of Topsham.

Copper. *See* Bornite, Chalcocite, and Chalcopyrite.

Epidote. Sagadahoc County, occurs at Phippsburg.

Essonite. Sagadahoc County, Phippsburg; Oxford County, found at several places.

Feldspar. Extensively quarried from pegmatite deposits. Androscoggin County, quarried at Apatite Hill, town of Auburn; Berry quarry, town of Poland; Lincoln County, has been quarried in town of Edgecomb; Oxford County, has been quarried at Hibbs quarry and Mills quarry, town of Hebron, at Mount Mica, town of Paris; Piscataquis County, has been quarried at Brownsville; Sagadahoc County, quarried at Golding's quarry, Georgetown, Willes quarries, town of Topsham; has been quarried at Mount Ararat and at Fisher's quarry, town of Topsham.

Flagstone. Mica schist suitable for flagging occurs in Kennebec County, at Winthrop; Sagadahoc County, at Phippsburg; York County, Acton and Lebanon; and at other localities; also sandstones in northern part of State.

Galena. Hancock County, occurs in Ellsworth schist near Blue Hill and Brooksville; Oxford County, in granite at Mount Glines; Penobscot County, in thin veins near Hampden and Corinna; Piscataquis County, at Dover; Somerset County, abundant at Bingham mine, small quantity at Robinson mine has been mined; Washington County, Cherryfield, Lubec lead mine, and Pembroke copper prospect.

Garnet. *See* Essonite.

Gold. Franklin County, associated with pyrite-bearing slates at Strong; Hancock County, has been mined in granite with molybdenite at Catharine Hill, is sparingly present with sulphides in Blue Hill mines, and in some river gravels and crevices in underlying rocks; Oxford County, has been found in some river gravels; Somerset County, occurs at Moscow, and in some river gravels; Washington County, in quartz veins at Bailey, Baring, and Cutler, and in some river gravels and in crevices in underlying rocks.

Granite. Quarried: Cumberland County, at Brighton, Brunswick, Portland, Pownal, Westbrook, and Woodfords; Franklin County, North Jay; Hancock County, Blue Hill, Brooksville, Dedham, Franklin, and elsewhere; Kennebeck County, Augusta, Hallowell, and Mainstream; Knox County, Long Cove, Pequoit, Rockland, South Thomaston, St. George, and elsewhere; Lincoln County, Round Pond and Waldoboro; Oxford County, Fryeburg and Oxford; Penobscot County, Lincoln, black granite at Hermon Hill; Piscataquis County, Guilford; Somerset County, Canaan and Norridgewock; Waldo County, Frankfort, Searsport, and Swanville; Washington County, Addison, Baileyville, Calais, Jonesboro, Marshfield, and Millbridge; York County, Alfred, Biddleford, and Kennebunkport.

Graphite (plumbago). Cumberland County, occurs in pegmatite dike near Yarmouth; Franklin County, in schist near Madrid; Hancock County, in pegmatite and schists near Blue Hill and Brooksville; Kennebec County, at Gardiner on the Kennebec River; Oxford County, sparingly in granite and mica schist in towns of Paris, Rumford, and Woodstock; Sagadahoc County, has been mined at Georgetown and Phippsburg; Waldo County, occurs at Belfast, disseminated through clay slate.

Hematite (red iron ore). Aroostook County, occurs at Curriers; Piscataquis County, has been mined at Katahdin mines.

Infusorial earth. Hancock County, was mined at Blue Hill and Surry; Washington County, was mined at Beddington.

Iron. *See* Brown iron ore, Hematite, and Magnetite.

Kunzite (spodumene). Oxford County, lilac-colored, occurs in pegmatite in town of Andover.

Lead. *See* Galena.

Lepidolite. Androscoggin County, in pegmatite deposits at Apatite Hill, and in the Wade and Pulsifer quarries, town of Auburn; Oxford County, at the Dunton quarry in the town of Newry, and at Mount Mica, town of Paris; Mount Rubellite, town of Hebron.

Limestone (lime). Knox County, extensively quarried and burned in vicinity of Rockland, Rockport, Thomaston, and West Warren.

Limonite. *See* Brown iron ore.

Magnetite (magnetic iron ore). Aroostook County, occurs at Linneus, impregnating slaty rock; Cumberland County, Raymond, in thin sheets in epidotic gneiss; Hancock County, in schist at Douglas, Twin Lead, Owen, and other mines near Blue Hill and Brooksville, and on Marshall Island; Knox County, Union; Oxford County, Buckfield.

Mica (biotite). Common in many pegmatite deposits of the State.

Mica (muscovite). Abundant in all of the pegmatite deposits. Oxford County, small quantities have been mined at Mount Mica, town of Paris, Bennett and Pingree farms, town of Albany, Hibbs quarry, town of Hebron, southwest part of town of Waterford.

Molybdenite (sulphide of molybdenum). Cumberland County, occurs in granite in close connection with pegmatite at a number of places in Brunswick; Hancock County, under similar conditions at Catharine Hill on Long Island in Blue Hill Bay; Washington County, Cooper, 22 miles southwest of Calais, with fluorspar and bismuth in narrow pegmatite dikes cutting granite along joints, and impregnations in granite.

Ocher. Androscoggin County, has been mined at Lisbon; Cumberland County, occurs at Bridgton, Naples, and Sarmonite.

Platinum. Knox County, in peridotite, East Union; Penobscot County, at Hermon; Piscataquis County, in pyrrhotite ores.

Pollucite. Oxford, found in pegmatite at Buckfield and Hebron.

Pyrargyrite (ruby silver). Hancock County, occurs at Sullivan, Franklin, and Hancock, with galena, native silver, silver glance, pyrite, chalcopyrite, etc., sparingly.

Pyrite. Hancock County, Douglas, Twin Lead, Blue Hill, and other mines in Blue Hill and Brooksville district, and in granite at Catharine Hill; Oxford County, in granite at Mount Glines; Somerset County, has been mined at Robinson mine; Washington County, Cherryfield, has been mined at Lubec lead mine.

Pyrrhotite. Hancock County, Douglas, Twin Lead, Monmouth, and other mines, have been mined; Knox County, Miller farm, East Union; Piscataquis County; Somerset County, Robinson mine.

Quartz. Abundant in all pegmatite deposits. White quartz: Androscoggin County, mined with feldspar at Apatite Hill, town of Auburn; Cumberland County, has been mined near Cumberland Mills. Rose quartz: occasionally used as a gem. Oxford County, Tubbs ledge and French Mountain, town of Norway; Mount Mica, town of Paris. Smoky quartz: Androscoggin County, occurs at Apatite Hill, town of Auburn; Oxford County, Blueberry Hill, town of Stoneham.

Rhodonite. Hancock County, was mined on Osgood farm, Blue Hill, when furnace of Katahdin Iron Works was in blast.

Sand (building). Dug at many places throughout State.

Sand (glass). Knox County, Camden, abundant; not mined; Waldo County, Liberty, pure, granular quartz.

Sandstone. Washington County, Devonian sandstone mostly unsuited for building purposes occurs near Perry.

Silver (native). Hancock County, reported from Eggemoggin and Sullivan mines *See also* Argentite, Cerargyrite, Pyrargyrite, and Stephanite.

Slate. Piscataquis County, slate region in central part of State, quarried at Barnard plantations, Blanchard, Brownville, Monson, and Williamsburg; Somerset County, prospect in southwest corner of town of Forks.

Sphalerite (zinc blende). Hancock County, occurs sparingly in Blue Hill copper deposits, argentiferous in Gouldsborough mine, has been mined; also found in Eggemoggin, Deer Isle, and other mines, and at Harborside; Somerset County, has been mined at Robinson mine; Washington County, has been mined at Cherryfield, also occurs at Pembroke copper prospect.

Stephanite (silver glance). Hancock County, reported from Sullivan mine.

Talc (soapstone). Hancock County, Harpswell, Jaquish, Deer Isle; Kennebec County, Ovis Island, bed 14 feet wide; Vassalboro.

Tin. *See* Cassiterite.

Topaz. Oxford County, Harndon Hill, town of Stoneham.

Tourmaline. Colored tourmalines of gem quality. Androscoggin County, mined at Apatite Hill, town of Auburn; has been mined at Wade and Pulsifer quarries, town of Auburn, Berry quarry, town of Poland; Oxford County, mined at Mount Mica, town of Paris; has been mined in town of Greenwood, at Mount Rubellite, town of Hebron, Mills quarry, town of Hebron, Dunton quarry, town of Newry; Sagadahoc County, Willes feldspar quarry, town of Topsham.

Tripolite (diatomaceous earth, "fossil meal"). Hancock County, occurs abundantly in all the pond bottoms near the coast, mined to some extent. A very white, fine variety occurs in Blue Hill ponds in beds from 4 to 6 feet thick.

Wad (bog manganese). Occurs in Aroostook County, at Hodgdon; Hancock County, at Blue Hill; Knox County, at Thomaston, on Dodges Mount; Oxford County, at Sumner; Piscataquis County, at Dover; York County, at Mount Agamenticus.

Zinc. *See* Sphalerite.

MARYLAND.

Asbestos (chrysotile). Baltimore and Harford counties, small, inferior deposits of fibrous serpentine have been quarried at several places; Cecil County, at West Nottingham.

Barite. Carroll and Frederick counties, lens-shaped bodies have been found.

Bornite (peacock copper). Carroll County, occurs at Mineral Hill, 7 miles southwest of Finksburg and near New Windsor; Frederick County, mined at Liberty mine between Union Bridge and Libertytown, occurs in Linganore copper region.

Brown iron ore (brown hematite, limonite). Was formerly mined more or less extensively at the following places: Allegany County, Nicholas Mountain and Shriver Ridge; Baltimore County, near Bosley, 2 miles west of Cockeysville, 2 miles west of Glencoe, near Lutherville, Stevenson, and Towson; Carroll County, at Avondale, Bachman Mills, Ebbvale, Lineboro, Melrose, and Westminster; Frederick County, east foot of Catoctin Mountains near Thurmont, near Feagaville, Frederick Junction, Unionville, and Washington Junction;

Harford County, at Hess, and 2 miles southwest of Jarrettsville; Washington County, 1 mile south of Boonsboro, 3 miles north and 4 miles southwest of Clear Spring, 1 mile and 3 miles northwest of Harpers Ferry, near Green Spring, 2 miles northeast and 1 mile southeast of Indian Spring, 1 and 2 miles south of Pondsville.

Brown iron ore (bog iron ore). Found at several localities in small quantity. Was mined and made into pig iron many years ago at Federalsburg, Caroline County, and on Nassawango Creek, Worcester County, latter locality producing as high as 700 tons in one year.

Calamine (zinc silicate). Carroll County, zinc mine near New Windsor, with sphalerite and smithsonite, not worked.

Cement (natural). Allegany County, Silurian limestone used for natural cement at Cumberland and Potomac; Baltimore County, Cockeysville and Texas; Carroll County, vicinity of Union Bridge; Washington County, at Cavetown, Cayuga, Chewsville, Hagerstown, Hancock, and Tonoloway station.

Cement (Portland). Allegany County, has been quarried at Cumberland and Pinto; Frederick County, Ordovician limestone suitable for Portland cement lies along Monocacy River in east-central part of county; Washington County, same rock in two belts, one north and south through center and one in east third of county, has been quarried at Round Top.

Chalcocite (copper sulphide). Carroll County, has been mined at Mineral Hill mine and Roop farm; Frederick County, mined occasionally at Liberty mine, occurs at Bare Hill and Dolly Hyde mines.

Chromite (chromic iron ore). Baltimore County, has been mined at Bare Hills and Soldiers Delight; Carroll County, occurs in a belt from near New Lisbon, through Montgomery County, nearly to Potomac River; Cecil County, formerly mined in small way along State line near Rock Springs; Harford County, was mined at several points in serpentine; Montgomery County, near headwaters of Seneca Creek in serpentine.

Chrysocolla (copper silicate). Carroll County, sparingly in red sandstone between Middleburg and Big Pipe Creek.

Chrysotile. *See* Asbestos.

Clay (brick and tile). Clay suitable for the manufacture of brick and tile are of common occurrence throughout the State. Common brick are made from sedimentary clays of the Coastal Plain, residual clays of the Piedmont region, and shaly deposits of the Appalachian region. There are 67 brick, tile, and terra-cotta works in the State, including 4 at Baltimore, 2 at Cambridge, 5 at Hagerstown, 3 at Salisbury, 3 at Westminster, and one or more at many localities in 16 different counties.

Clay (fire). Allegany County, worked at Cumberland, Frostburg, and Mount Savage; Baltimore County, Pleistocene and residual clays of Algonkian, worked at 4 places; Cecil County, 4 yards near Northeast; Frederick County, 1 yard at Frederick; Wicomico County, 1 yard at Salisbury.

Clay (kaolin). Cecil County, residual, white, derived from feldspathic gneisses, is used chiefly in manufacture of paper.

Clay (pottery). Anne Arundel County, important outcrops along western shore of Chesapeake Bay from Bodkin Point southward; Cecil County, found at many places in Patapsco formation; pottery clay is worked near Baltimore, Catonsville, Cumberland, Frederick, and Hagerstown.

Coal (bituminous). Occurs in five basins, known as Castleman, Georges Creek, Upper Potomac, Lower Youghiogheny, and Upper Youghiogheny, all in Allegany and Garrett counties; Pittsburg principal seam, mines from Frostburg to Midland; Ocean, Union, and Carlos largest mines; lower beds of Allegheny formation extensively mined from Moscow to Westernport, at Lonaville, Barrellville, and along west bank Potomac River on east border of Garrett County; Lower Kittanning coal (in Allegheny formation), 6 feet, mined North Potomac Valley; Mercer coal bed (in Pottsville formation), 2-4 feet, mined for firing brick at Mount Savage, also mined to slight extent near Westernport; Pittsburg coal (in Monongahela formation), 5-20 feet, extensively mined in Georges Creek district; high-grade steam and blacksmith coal.

Copper (native). Frederick County, Catoctin Mountain, specimens only.

Copper ores. *See* Bornite, Chalcocite, Chrysocolla, and Malachite.

Diabase. *See* Road metal.

Dolomite. Quarried in Baltimore County, and near Hagerstown, Washington County.

Feldspar. Baltimore County, orthoclase and microcline mined near Woodstock, Granite, and Hollofield, and across the line in Howard County; Montgomery County, 4 miles west of Laurel, microcline mined; Cecil County, soda feldspar, albite, mined near Conowingo.

Flagstone. Frederick County, Catoctin Mountain, Emmitsburg, High Knob, near Frederick.

Flint. *See* Quartz.

Fluorspar (fluorite). Allegany County, occurs near Cumberland.

Gabbro. Baltimore County, quarried at Dickeyville and Woodberry; Harford County, near Havre de Grace; Howard County, Savage. *See also* Road metal.

Galena (lead ore). Baltimore County, traces in Jones Falls quarries; Carroll County, with limestone in western part of Carroll and eastern part of Frederick County; Montgomery County, has been mined for gold in Maryland mine at Great Falls.

Gneiss. Quarried at Baltimore; and in Baltimore County, at Loch Haven, Pikesville, Phoenix, Stevenson, and opposite Ellicott City.

Gold. Baltimore County, found in quartz veins at Catonsville; Carroll County, found in small quantity at Mineral Hill; Montgomery County, was mined with pyrite, galena, etc., at Great Falls.

Granite. Cecil County, quarried extensively at Port Deposit.

Hematite (Clinton oolite). Allegany County, was stripped many years ago on west side of Wills Mountain, near Roberts and near Cumberland; it occurs in three areas, Wills Mountain, Evitts Mountain, and Tussey Mountain.

Hematite (specularite). Carroll County, was formerly mined at Springfield and Carroll mines near Sykesville, Mineral Hill mine near Louisville, and Patapsco mines at Finksburg.

Infusorial earth. Bed 30 feet thick at base of Miocene has been traced from Herring Bay on the Chesapeake to Popes Creek on the Potomac, across Anne Arundel, Calvert, and Charles counties; has been dug for polishing powder; chief production at Lyons Creek on Patuxent River, Anne Arundel County.

Iron ores. *See* Brown iron ore, Chromite, Hematite, Magnetite, Pyrite, Pyrrhotite, and Siderite.

Limestone (building). Very little limestone is quarried for dimension building stone; small quantities are taken at a few places for local use.

Limestone (crushed stone). Quarried: Allegany County, at Cumberland; Baltimore County, Baltimore, Glyndon; Frederick County, Catoctin Furnace, Frederick, Lime Kiln; Washington County, Cavetown, near Hagerstown, at Maugansville, Pinesburg, and elsewhere.

Limestone (lime). Quarries where stone is or formerly was procured to burn for lime: Allegany County, Cumberland, and near Allegany Grove; Baltimore County, Butler, Dover, Glyndon, and Texas; Carroll County, Avondale, Linwood, Uniontown, Union Bridge, near Westminster, and elsewhere; Frederick County, Buckeystown, Catoctin Furnace, Daysville, Mount Pleasant, Mount Savage, and elsewhere; Howard County, Clarkville, Fulton, and Highland; Washington County, Cavetown, Cayuga, Chewsville, Clear Spring, Hagerstown, Pinesburg, and elsewhere.

Limonite. *See* Brown iron ore.

Linnæite (siegenite, cobalt pyrites). Carroll County, Mineral Hill copper mines, Finksburg, in small quantities with copper ores in chlorite schist.

Magnetite. Baltimore County, was mined 1 mile southeast and 2½ miles northeast of Whitehall; Frederick County, 15,000 or more tons of ore were taken on hill southwest of Catoctin Furnace, near Thurmont; Harford County, small quantity was mined 1 mile southeast of Minefield. Besides these places where magnetite has been mined, there are several mines and prospects where it has been found in very small quantity or might be found by driving through the limonite cap.

Malachite (green carbonate of copper). In Blue Ridge district and crystalline rocks of Frederick, Carroll, Howard, and Baltimore counties; Liberty mine, Frederick County, only producer.

Manganese ore. Reported in small quantities in Cambrian and Ordovician rocks at following localities: Allegany County, Keysers Ridge and Bear Creek, Youghiogheny Valley; Frederick County, New Market, associated with copper; Montgomery County, at Brookville and Mechanicsville; Washington County, north shore of Potomac, 3 miles north of Harpers Ferry; pyrolusite has been mined.

Marble. Baltimore County, at Cockeysville, fine dolomitic marble quarried for building and decorative purposes; at Texas, coarse-grained, quarried for flux and lime; Carroll County, a few miles south of Union Bridge, variegated marble suitable for decoration; development work begun; Frederick County, Liberty, New Market, Sams Creek, variegated; east slope Catoctin Mountain, "Potomac or calico marble"; valley of Monocacy River; Washington County, Eakles Mills and Boonsboro, cream-colored and variegated, has been quarried; Benevola and Hagerstown, quarried.

Marl (greensand). Glauconitic, occurs abundantly in Anne Arundel, Charles, Kent, and Prince Georges counties.

Marl (shell). Occurs abundantly in Calvert, Caroline, Queen Annes, St. Marys, and Talbot counties. Caroline County, deposit in bank of Choptank River, near Denton, has been used for road material.

Mica (muscovite). Baltimore County, with quartz and feldspar in quarry near Hollofield Station; Howard County, has been quarried 1½ miles north of Scaggsville and near Woodstock; Montgomery County, prospects 4 miles northwest of Laurel on south side of Patuxent River.

Ocher. Anne Arundel and Prince Georges counties, was formerly mined from Patapsco and Arundel formations; Frederick County, considerable shipments from Catoctin Furnace pits.

Pyrite. Anne Arundel County, in Magothy formation on Magothy River, was roasted for sulphuric acid; Montgomery County, abundant in quartz at Maryland mine near Great Falls; Prince Georges County, Oxon Creek, was mined for gold.

Pyrolusite. Frederick County, near Point of Rocks; Montgomery County, Brookville, abandoned mines; Washington County, was mined on north shore of Potomac, 3 miles north of Harpers Ferry.

Pyrrhotite. Howard County, in small quantities with hornblende near Woodstock.

Quartz. Baltimore County, quarried at Glen Morris and Woodstock; Carroll County, Louisville; Harford County, Flintville, Deer Creek, and 1½ miles west of Conowingo (Cecil County); Howard County, Marriotsville; all ground for use in pottery manufacture; Montgomery County, mined 4 miles west of Laurel with mica and feldspar.

Road metal. Gabbro, extensive in Baltimore, Cecil, Harford, Howard, and Montgomery counties; diabase, long narrow outcrops in Baltimore and Howard counties, more extensive in Frederick and Montgomery counties; marble, limestone, and sandstone, extensive in valleys north of Baltimore City, and in Frederick and Hagerstown valleys; gravels and marls, Anne Arundel, Calvert, Cecil, Charles, Kent, Prince Georges, Queene Annes, and Talbot counties.

Sand (building). Anne Arundel and Baltimore counties, dug and dredged near Baltimore; Prince Georges County, Farmington; Washington County, Hancock.

Sand (glass). Anne Arundel County, dug at Robinson; has been worked on both banks of upper part of Severn River. Allegany and Washington counties; occurs in Silurian and Devonian deposits.

Sand (molding). Anne Arundel County, dug at Magothy River; Baltimore County, Catonsville; Washington County, Rock Forge. Found also in Cecil, Harford, and Kent counties.

Sandstone (building). Quarried in small quantity in Allegany County, at Cumberland; Carroll County, at Taneytown; Montgomery County, near mouth of Seneca Creek.

Sandstone (crushed stone). Allegany County, quarried at Cumberland; Garrett County, Bloomington.

Serpentine. Baltimore County, quarried at Bare Hills and Reistertown; Cecil County, forms wall rock at West Nottingham quarry; Harford County, quarried at Dublin, has been quarried at Broad Creek, near Cambria, at Coopstown, and Deer Creek.

Siderite (spathic iron ore). Confined to Cretaceous deposits of Coastal Plain; found in Anne Arundel, Baltimore, Cecil, and Prince Georges counties; ore occurs in lenses in clay. A large number of ore banks are found on a line from Poplar, through Baltimore, Eldridge, Annapolis Junction, Murkirk, to Branchville.

Silver. Frederick County, Catoctin Furnace, in sphalerite and galena.

Slate. Frederick County, has been quarried at Ijamsville and Bennett Creek, near Thurston; Harford County, quarried for roofing in Peachbottom area, Cardiff; Montgomery County, occurs at Hyattstown.

Smithsonite (carbonate of zinc). Carroll County, zinc mine near New Windsor, with sphalerite and calamine; has been mined.

Soapstone. Small quantity sawn into slabs, more ground for acid and fireproof paints. Carroll County, quarried from extensive deposit northwest of Marriottsville; small quantity ground near Westminster; Cecil County, Patersons on west branch of Northeast River; New Leeds on Little Elk; Harford County, soapstone occurs but quarrying abandoned; Montgomery County, near Cloppers Mills, Rockville, and Smells Bridge.

Sphalerite (zinc blende). With crystalline limestone in west part of Carroll County, and east part of Frederick County.

Stibnite. Frederick County, Middletown Valley.

Talc (French chalk). Cecil County, Rock Springs, in serpentine; Montgomery County, 6 miles from Rockville on Darnestown road.

Tetradymite. Montgomery County, has been mined with gold in Great Falls mines.

Tourmaline. Montgomery County, chrome tourmaline near Etchison.

Verde antique. *See* Serpentine.

Zaratite (emerald nickel). Cecil County, small quantity in chrome ore mine in northern part of county.

Zinc. *See* Calamine, Smithsonite, and Sphalerite.

MASSACHUSETTS.

Alum. Dukes County, lignitic clays in vicinity of Gay Head and elsewhere on Marthas Vineyard, once shipped to Salem for alum.

Anthracite. *See* Coal.

Aquamarine. Found at Royalston and Fitchburg. *See also* Beryl.

Asbestos. Berkshire County, was mined in connection with talc at Dalton; Hampshire County, mined near Pelham.

Beryl. Worcester County, at Royalston, best locality in State, blue and yellow gem quality, worked intermittently. Found also in Franklin County at Northfield; Hampden County, Blandford; Hampshire County, Chesterfield, Goshen, and Norwich.

Beryl (emerald). Hampshire County, reported specimens found at Chesterfield and Goshen.

Brown iron ore (limonite, bog iron ore). Dukes County, deposits in swamps and in Tertiary rocks in Marthas Vineyard; Hampden County, formerly worked near Brimfield.

Brown iron ore (brown hematite). Berkshire County, numerous and extensive beds in Richmond, has been mined to some extent; Bristol County, large quantities at Dartmouth and Easton, has been mined at West Stockbridge.

Chalcopyrite (copper pyrites). Essex County, with galena, pyrite, etc., middle vein, Newburyport lead mines; Franklin County, occurs in very small quantity at Davis, Greenfield, Leverett, Montague, and elsewhere, was shipped from Davis mine; Hampshire County, Loudville and Southampton; Worcester County with siderite in mica slate at Sterling.

Chiastolite. Worcester County, good specimen locality in argillaceous slate at Westford and Lancaster; abundant gem quality, some cut.

Chromite (chromic iron ore). Hampden County, in serpentine at Chester, three outcrops 5 to 18 inches wide; 1,200 pounds of ore once obtained.

Clay (brick). Dug in following places: Barnstable County, at West Barnstable; Berkshire County, Braytonville; Bristol County, near Taunton; Dukes County, Gay Head; Essex County, Danvers, Danversport, Salisbury, and elsewhere; Franklin County, Turners Falls, Montague City, and elsewhere; Hampton County, Springfield, West Brimfield, and Williamsette; Hampshire County, Amherst, Easthampton, Northampton, and elsewhere; Middlesex County, Belmont, Cambridge, and Medford; Plymouth County, Bridgewater, Middleboro, Plymouth, and elsewhere; Suffolk County, Chelsea and Revere; Worcester County, East Brookfield, South Fitchburg, Still River, and elsewhere.

Clay (fire). Dug in Bristol County, at Fall River; Dukes County, Chilmark, Gay Head, and Mahonikey.

Clay (kaolin). Berkshire County, occurs 4 miles south of Clayton; Dukes County, occurs at Gay Head and elsewhere; Hampden County, dug at Blandford.

Clay (plastic). Barnstable County, occurs at Truro on Cape Cod; Dukes County, abundant in southeastern part of Chilmark and at Gay Head, Marthas Vineyard; Nantucket County, Nantucket; Plymouth County, beneath sands at Duxbury.

Clay (pottery). Dukes County, underlies district from Tisbury Brook westward to cliffs at Gay Head, Marthas Vineyard, mined at Gay Head; Essex County, mined at Danvers, shipped, not used locally.

Coal (anthracite). The Rhode Island coal field extends northeast into this State and small quantities of coal were mined years ago in Bristol County, at Mansfield; Norfolk County, at Wrentham; Plymouth County, at Middleboro and West Bridgewater. The coal is graphitic and not suitable for domestic fuel. The so-called coal at Worcester is graphitic phyllite and that on the bank of Agawam River at West Springfield is of somewhat the same character. *See also* Lignite.

Corundum (emery). Hampden County, has been mined in vicinity of Chester, at Sacket, Wright, and other mines, and with asbestos at Pelham.

Cyanite. Hampshire County, Chesterfield.

Diabase. *See* Trap rock.

Feldspar. Hampden County, small quantities quarried near Blandford.

Flagstone. Berkshire County, Washington; Franklin County, Montague, red micaceous sandstone was quarried.

Fluorspar. Franklin County, occurs at Conway, Deerfield, and Northfield; Hampshire County, occurs in Southampton lead mine, near Northampton, and West Springfield.

Fuller's earth. Worcester County, produced in 1904 at Lancaster.

Galena. Hampden County, was formerly mined at Montgomery; Hampshire County, argentiferous galena in masses to more than 1 foot in diameter were found in Southampton lead mine.

Garnet. Franklin County, many stones almost suitable for cutting on Northfield Mountain; Hampden County, fine crystals at Chester and Russell, large quantity was obtained from Russell.

Gneiss. Franklin County, has been quarried at Montague; Hampden County, Wilbraham and Monson; Worcester County, Boylston, Dudley, Milbury, Westboro, and Uxbridge.

Granite. Quarried at following places for building, monuments, paving, etc.: Berkshire County, Becket; Bristol County, Dartmouth and Fall River; Essex County, Lynn, Peabody, and Rockport; Franklin County, Warwick; Hampden County, Chester and Monson; Hampshire County, Pelham; Lowell County, Westford; Middlesex County, Dunstable, Grantsville, Hopkinton, and Westford; Norfolk County, East Weymouth, Milton, Quincy, and Wrentham; Plymouth County, East Hingham; Worcester County, Fitchburg, Milford, Oxford, and elsewhere. Principal quarrying centers are Becket, Milford, Quincy, and Rockport.

Graphite. Franklin County, impure bed about 5 feet wide reported at Charlemont; Worcester County, in gneiss at Sturbridge; has been mined.

Grindstones (millstones). An argillaceous slate suitable for grindstones found at Charlestown, Malden, and Quincy. Berkshire County, millstone produced at Washington.

Hematite. Franklin County, has been mined in small way at Bernardston, Montague, and Warwick; Hampshire County, at Hawley.

Infusorial earth. Middlesex County, has been mined at Framingham.

Jade. Middlesex County, has been obtained at Framingham; possibly williamsite and not true jade.

Jasper. Essex County, Saugus; Franklin County, in mica slate at Conway; Middlesex County, has been mined at Framingham.

Lead. *See* Galena.

Lignite (brown coal). Dukes County, Marthas Vineyard, 50 tons mined in 1908, none since.

Limestone (building). Berkshire County, quarried at North Adams; Middlesex County, Acton, Carlisle, Chelmsford, Littleton, and Stoneham; Worcester County, has been quarried at Bolton.

Limestone (lime). Berkshire County, burned at Adams, Cheshire, and elsewhere.

Limonite. *See* Brown iron ore.

Magnetite (magnetic iron ore). Franklin County, considerable quantity of iron sand at Montague; Hampden County, large quantity impure at Warwick, considerable quantity has been mined at Sacket mine, Chester; Hampshire County, small bed at Plainfield.

Marble. Berkshire County, quarried at Ashley Falls, Lee, and North Adams; Hampden County, at Westfield.

Marl. Berkshire County, occurs at Lenox, Pittsfield, and Williamstown; Plymouth County, considerable quantity at Duxbury.

Mica (muscovite). Worcester County, at Beryl Hill, Royalston; has been prospected recently.

Mineral paints. Berkshire County, ocher and sienna were once worked at Williamstown; Franklin County, at East Whately.

Novaculite. Middlesex County, in beds of argillaceous slates at Malden; Norfolk County, Quincy; Suffolk County, Charlestown; not used.

Peat. Numerous deposits in swamps and bogs principally in eastern and central parts of State.

Psilomelane. Franklin County, in quartz veins at Conway; Hampshire County, with slate near Plainfield; not mined.

Pyrite (iron pyrites). Franklin County, Davis mine near Rowe, cupriferous, shipping; Worcester County, mined for copperas at Hubbardston.

Pyrolusite. Franklin County, in quartz veins at Conway; Hampshire County, in beds 3 feet thick at Plainfield.

Pyrrhotite. Franklin County, in veins in gneiss at Charlemont; Hampden County, in Chester emery mine.

Quartz. Berkshire County, quarry near Cheshire.

Rhodonite. Berkshire County, at Sheffield; Franklin County, Conway and Hawley; Hampshire County, fine material in Silurian schist at Cummington; has been mined for ornaments.

Road metal. *See* Granite and Trap rock.

Sand (building). Dug in following places: Berkshire County, at Williamstown and North Adams; Essex County, Lawrence and Methuen; Middlesex County, Watertown; Norfolk County, Walpole; Plymouth County, East Bridgewater and East Wareham; Suffolk County, Boston and Brighton; Worcester County, Worcester; and at many other places.

Sand (glass). Berkshire County, large supply from granular quartzite at Cheshire and Washington; Dukes County, Tertiary sands abundant at Gay Head and vicinity Marthas Vineyard, probably suitable for glass making.

Sand (molding). Dug in Berkshire County, at Cheshire; Plymouth County, East Bridgewater; Worcester County, Worcester.

Sandstone. Hampden County, quarried at East Longmeadow and Holyoke; Suffolk County, Boston, Brighton, and Jamaica Plains, building and crushed stone; Franklin County, has been quarried at Deerfield; Hampshire County, Granby.

Schist. Hampshire County, mica schist was quarried at Chesterfield and Goshen.

Serpentine. Beds extend across State from Rowe to Granville. Berkshire County, occurs at Windsor; Franklin County, on north side of Deerfield River in Zoar; Hampden County, in west part of Westfield; Hampshire county, Middlefield and Hoosac Mountain; Middlesex County, Chelmsford and Littleton.

Siderite (spathic iron ore). Berkshire County, at West Stockbridge, with limonite ore; Dukes County, Gays Head, Marthas Vineyard, in clay; Essex County, Newburyport, with galena at the silver-lead mine in middle vein in small quantities; Worcester County, in mica slate in Sterling and Worcester.

Slate. Franklin County, Connecticut River slate quarried at Bernardston; Middlesex County, has been quarried at Somerville; Norfolk County, argillaceous slate extensively quarried at Quincy; Suffolk County, Charlestown, for gravestones, flagging, etc.; Worcester County, Harvard, Lancaster, Pepperell, and Shirley; has been quarried at Lancaster for roofing and gravestones.

Soapstone. Berkshire County, has been quarried at Windsor; Hampden County, Blandford; Hampshire County, fine bed associated with serpentine in northeast part of Middlefield; Middlesex County, Groton; Worcester County, Worcester.

Sphalerite (zinc blende). Essex County, has been mined at Newburyport lead mines; Hampshire County, principal ore in vein at Northampton; Worcester County, considerable quantity in mica slate at Sterling.

Spinel (ruby, pleonaste). Middlesex County, in limestone at Littleton and Boxboro; Worcester County, specimen once found at Bolton.

Talc. Berkshire County, mined near Hoosac tunnel and Dalton; Franklin County, mined and milled at Rowe and Zoar; Hampshire County, has been mined in Middlefield. Occurs in small quantity in several other places associated with serpentine.

Tetrahedrite (gray copper ore). Essex County, in lead mine, Newburyport, in small quantities with galena, pyrite, chalcopyrite, and siderite.

Tourmaline. Berkshire County, has been found in limestone at Dalton; Hampden County, at Sacket mine near Chester; Hampshire County, Huntington and asbestos mine at Pelham.

Trap rock. Quarried in Essex County, at Beverly, Methuen, Salisbury, and elsewhere; Franklin County, East Deerfield; Hampden County, Westfield and West Springfield; Hampshire County, Amherst; Middlesex County, Medford, Newton, Weston, and elsewhere; Norfolk County, Brookline and North Stoughton; Suffolk County, Franklin Park and Roxbury; Worcester County, Sterling.

Verde antique. Berkshire County, occurs at Becket; Essex County, at Newbury; Hampden County, at Westfield. *See* Serpentine.

Wad. Berkshire County, occurs at Sheffield; Franklin County, Conway, Leverett, and Whately; Hampshire County, Chesterfield and Plainfield.

Whetstone. Hampshire County, mica schist quarried at Enfield and Huntington; Norfolk County, extensive quarries in northeastern part of Bellingham.

Wulfenite (molybdate of lead). Hampshire County, found in Manhan lead mine, Loudville, and in Southampton.

Zinc. *See* Sphalerite.

MICHIGAN.

Agate. Amygdules and pebbles found at many places along shore of Lake Superior are polished for jewelry. Agates from Petoskey are mainly polished limestone corals.

Amethyst. Occasional good specimens in trap rock of Keweenaw Point.

Anhydrite. Salt shaft at Oakwood, South Detroit; very widespread according to drillings.

Bromine. Produced from brine in Crawford County at Grayling; Gratiot County, St. Louis (idle); Huron County, Harbor Beach; Isabella County, Mount Pleasant; Midland County, Midland; Saginaw County, St. Charles and Saginaw. Up to 2,000 parts per million in deep copper mine waters.

Cement material (Portland). Limestone for Portland cement quarried at Alpena County, Alpena; Eaton County, Bellevue; Emmet County, Petoskey; Monroe County, Dundee; Newaygo County, Newaygo; and Wayne County, Sibley and Bellevue, near Trenton. Suitable limestone also occurs at Arenac County, Omer; Charlevoix County, Bayshore and Charlevoix; Huron County, Bayport and Sebewaing; Cheboygan County, Afton; Jackson County, near the Portage River 5 or 6 miles north of Jackson; Presque Isle County, Onaway; but is not used.

Marl more largely used in cement manufacture, obtained from a large number of localities distributed over the entire State. The more important localities are in Alpena, Antrim, Branch, Crawford, Genesee, Hillsdale, Jackson, Lenawee, Livingston, Mason, Ogemaw, St. Joseph and Washtenaw counties.

Shale is quarried for cement manufacture in Alpena County, 7 miles north of Alpena; Branch County, at Coldwater, near Union City and (formerly) at Bronson; Eaton County, Bellevue; Newaygo County, Newaygo. Suitable shales are found, but not used at present, on the shores of Thunder Bay and at several localities in Charlevoix County.

Chrysocolla. Keweenaw County, at Allouez mine; Ontonagon County, Algomah mine at Lake Mine.

Chlorastrolite. Keweenaw County, collected and cut as gem stone at Isle Royale and occasionally found near Porcupine Mountain and Mandan.

Clay (brick). Obtained from small local deposits over greater part of State. Important localities are: Eaton County, Grand Ledge; Huron County, Sebewaing; Ingham County, Lansing; Ionia County, Ionia; Jackson County, Jackson; Kalamazoo County, Kalamazoo; Shinawassee County, Corunna; Wayne County, Detroit; Wexford County, Harriette. Clay suitable for sewer pipe, vitrified brick, in connection with Saginaw Valley coal mines, especially in Bay County, at West Bay City; Eaton County, large pits at Grand Ledge; Genesee County, at Flushing. *See also* Cement material and Shale.

Clay (fire). Eaton County, mined at Eaton for sewer pipe and fireproof tile; Jackson County, Spring Arbor coal mines at Batcheldor Place; was formerly mined at Jackson.

Clay (pottery). Ionia County, glacial drift used for pottery at Ionia; Jackson County, 5 miles west of Jackson, not worked; Washtenaw County, glacial drift used for pottery at Ann Arbor; Wayne County, at Detroit; Wexford County, at Harriette, not worked.

Clay (slip). Ontonagon County, mined at Rockland.

Coal (bituminous). Coal basin covers an area of approximately 11,000 square miles. Principal developments in the eastern portion of the field and in a line from Bay City, Bay County, south to Jackson, Jackson County. More important operations in Bay, Greene, and Saginaw counties, though coal also mined in Clinton, Eaton, Jackson, Shiawassee, and Tuscola counties. All of the coal produced is of the noncoking, bituminous variety.

Copper (native). Large quantity mined in Houghton, Keweenaw, and Ontonagon counties, Lake Superior region. Nuggets in glacial drift of both peninsulas, more or less changed to carbonates.

Datolite. From copper mines of the northern peninsula; cut as a gem.

Diamond. Berrien County, one found at Buchanan in glacial drift.

Flagstone. Jackson County, has been quarried at Napoleon.

Gold. Marquette County, Ropes mine, near Ishpeming, T. 48 N., R. 27 W., free gold with auriferous pyrite, chalcopyrite, etc. Also several prospects in T. 48 N., R. 28 W., colors reported in glacial drift.

Granite. Abundant in Upper Peninsula. Only small quantity quarried, and quarries idle since 1909.

Graphite. Baraga County, graphitic slate milled at L'Anse; Marquette County, mine between that place and Humboldt.

Grindstone. Huron County, quarried at Port Austin and Grind Stone City; Sanilac County, sandstone of Marshall formation quarried in Austin township for grindstone.

Gypsum. Iosco County, mined at Alabaster; Kent County, near Grand Rapids and Grandville. Occurs also in northern Arenac County and southeast Ogemaw County, not mined; Mackinac County, near Point Aux Chenes, 7 miles west of St. Ignace, and in the vicinity of St. Martins Bay, not mined at present. *See* Anhydrite.

Hematite. The most important iron ore of the State; mined at the following places: Dickinson County, Iron Mountain, Loretto, Norway, Quinnesec, Randville, Vulcan, and Waucedah; Gogebic County, Bessemer, Ironwood, and Wakefield; Iron County, Amasa, Crystal Falls, Iron River, Mansfield, Stambaugh; Marquette County, Champion, Gwinn, Humboldt, Ishpeming, Michigamme, Negaunee, Palmer, Princeton, Republic.

Iron. *See* Hematite, Magnetite, and Marcasite.

Jaspilite. Marquette County, quarried for road metal at Ishpeming and Negaunee.

Limestone. Extensively quarried in Alpena County; Eaton County, at Bellevue; and Wayne County, Sibley, for use in sodium bicarbonate, soda ash, etc. *See also* Cement material.

Limestone (building). Quarries in Alpena County, at Alpena; Arenac County, Omer; small quantity quarried in Emmet County, at Petoskey; Huron County, Bay Port; Kent County, Grand Rapids; Menominee County, Menominee; Monroe County, Monroe and Maybee.

Limestone (crushed stone). Quarried and crushed in Alpena, Charlevoix, Cheboygan, Delta, Emmet, Huron, Mackinac, Menominee, Monroe, Oakland, Schoolcraft, and Wayne counties.

Limestone (flux). Quarried in Alpena, Emmet, Mackinac, Monroe, Presque Isle, and Schoolcraft counties.

Limestone (lime). Quarried and burned in Alpena, Charlevoix, Eaton, Emmet, Huron, Jackson, Kent, Monroe, Sanilac, Schoolcraft, and Wayne counties.

Magnetite. Occurs in small quantities in metamorphosed iron formation in Pehokee-Gogebic Range.

Manganese ore. Manganiferous iron ore mined in Gogebic district; occurs near Copper Harbor, Keweenaw Point, not now mined.

Marble. Dickinson County, formerly quarried at Metropolitan.

Marcasite. Bay County, in several mines in Lower Verne coal bed; Huron County, abundant in coal mines of Sebewaing and in shales at Point Aux Barque lighthouse; formerly mined in connection with coal.

Marl. Antrim County, mined for polishing powder and burned for lime at Lake Wetzell and other places; Monroe County, was formerly mined for polishing powder north of Plaisance Creek. *See also* Cement material.

Natural gas. Macomb, Oakland, and St. Clair counties; local consumption.

Peat. Large deposits throughout the State, especially in northern peninsula. In southern peninsula has been utilized to slight extent in manufacture of fuel, paper, and peat litter. Peat fuel plant was operating at Kalamazoo in 1911.

Important localities are in following counties: Chippewa, Clare, Eaton, Jackson, Kalamazoo, Kent, Lenawee, Luce, Mackinac, Mecosta, Ottawa, St. Clair, St. Joseph, Sanilac, Shiawassee, Tuscola, Van Buren, and Washtenaw.

Petroleum. Near Port Huron, Saginaw, and Allegan; production unimportant.

Quartz. Marquette County, mined at Ropes mine, near Ishpeming for abrasive.

Quartzite. Marquette County, used for road metal, Marquette.

Road metal. *See* Jaspilite, Limestone, Quartzite, and Trap rock.

Salt. From natural brine at Bay City, Midland, Saginaw, and St. Charles. Dissolved from rock salt: Mason County, at Ludington; Manistee County, Manistee, Filer City, and Eastlake; St. Clair County, Marine City and Port Huron; Wayne County, Delray, Detroit, Ecorse, and Wyandotte. Rock salt mined only at Oakwood shaft, South Detroit, just outside city limits.

Sand (building). Abundant throughout the State.

Sand (glass). Monroe County, Sylvania sandstone member of Monroe formation [illegible] quarried; shipped to Saginaw.

Sand (molding). Used in following places: Berrien County, at St. Jo[illegible] Calhoun County, Battle Creek; Eaton County, Dimondale; [illegible]

Lansing; Jackson County, Jackson; and Tuscola County, Cass City. Occurs, but is not utilized, in Delta, Genesee, Kent, Marquette, and Wayne counties.

Sandstone. Has been quarried at Baraga County, numerous quarries in L'Anse; Calhoun County, Battle Creek; Eaton County, Grand Ledge; Genesee County, Flushing; Houghton County, Jacobsville; Huron County, Grind Stone City near Rush Lake; Jackson County, Springport, Parma, Sandstone, and Napoleon; Keweenaw County, Isle Royale; Marquette County, Marquette; Monroe County, Ottawa Lake.

Shale. Largely quarried for cement materials. Also quarried for manufacture of brick in Bay County, at Bay City; Charlevoix County, East Jordan; Genesee County, Flushing; Ionia County, Ionia; and Shiawassee County, Corunna.

Silver (native). Small quantity mined with copper in Houghton, Keweenaw, and Ontonagon counties, Lake Superior region. Formerly mined on Silver Islet. Associated with copper, made into so-called "half-breed" jewelry.

Slate. Baraga County, at Arvon; not quarried.

Specularite. Occurs with hematite. *See* Hematite.

Thomsonite. Keweenaw Point amygdules and Lake Superior pebbles; polished for jewelry.

Trap rock. Used for road metal, Marquette, Marquette County, and on Copper Range.

Whetstone. Huron County, quarried at Grind Stone City, Port Austin, and elsewhere; Ontonagon County, novaculite along Carp River between Jackson Forge and Teal Lake; was formerly quarried.

MINNESOTA.

Brown iron ore (limonite). St. Louis County, large production from Mesabi iron range, and Vermilion Range. Large quantities in contact plane of Cretaceous on Silurian and Devonian, as in Brown, Lesueur, Fillmore, and other counties; also in Cuyuna district.

Calcite. Houston County, large mass at sand quarry near Caledonia suitable for quicklime.

Catlinite (pipestone). Pipestone County, in many localities; largely worked into articles of use and ornament.

Cement material (natural). Blue Earth County, "Lower Magnesian" (Ordovician) limestone used at Mankato; and Mower County, Austin.

Cement material (Portland). Fillmore County, "Trenton" limestone in vicinity of Wykoff and Spring Valley; not used.

Chalcocite (copper glance). Chisago County, occurs in Taylors Falls, argentiferous, and at Pigeon Point; of little importance; Pine County, near Pine City on Snake River.

Chalcopyrite (copper pyrites). Itasca County, occurs in Rainy Lake region; St. Louis County, near Tower.

Clay (brick). Utilized in nearly every county in the State.

Clay (fire). Brown County, has been dug at New Ulm; Redwood County, Redwood Falls; Steele County, dug 1 mile east of Owatonna.

Clay (pottery). Dug in Blue Earth County, near Mankato; Brown County, New Ulm; Goodhue County, extensively dug at Red Wing; Hennepin County, Northtown; Steele County, 1 mile east of Owatonna. Itasca County, Cretaceous clays suitable for pottery, not used.

Copper. (native). Keweenawan series ("Cupriferous") extends into northeastern part of the State in Chisago, Cook, Pine, and St. Louis counties; of no commercial importance to date.

Copper minerals. *See* Chalcocite and Chalcopyrite.

Feldspar. Lake County, considerable quantity quarried, ground at Duluth; St. Louis County, at Point Corundum near Duluth, and at Rices Point.

Flagstone. Blue Earth County, Mankato, on Minnesota River; Brown County, New Ulm; Lesueur County, Ottawa and Kasota; Nicollet County, Redstone; and valley of Minnesota (red quartzite); magnesian limestone on Mississippi, from Winona, Winona County, to Hastings, Dakota County, and thence to Stillwater, Washington County.

Galena. Itasca County, has been mined in Rainy Lake region. Small quantities here and there in "Trenton" limestone in southern part of State.

Gneiss. Redwood County, quarried at Redwood Falls.

Gold (lode). Beltrami County, occurs in many prospects in Archean rocks around Lake of the Woods and near Rat Portage; Itasca County, was mined in Rainy Lake region; St. Louis County, occurs near Vermilion Lake, in quartz in talcose slate, and with pyrite; workings abandoned.

Gold (placer). Fillmore County, small amounts in drift of Spring Valley and Jordan; Olmsted County, along streams; Wabasha County, Chester, and elsewhere.

Granite. Quarried in Benton County, at Sauk Rapids (syenite); Bigstone County, has been quarried near Ortonville; Itasca County, Giants Range north of Mesabi Range, also north of Net Lake and elsewhere; Kanabec County, Mora; Lac Qui Parle County, 3 miles southeast of Big Stone; in Redwood County; Renville County, Morton; St. Louis County, Duluth; Sherburne County, Haven; Stearns County, Rockville, and in vicinity of St. Cloud.

Hematite (red iron ore). St. Louis County, large quantity, many mines, in Mesabi, Vermilion, and Cuyuna ranges. Shipments amount to millions of tons annually.

Hematite (specular iron ore). Mined in Cook and Itasca counties.

Iron. *See* Brown iron ore, Hematite, Magnetite, and Pyrite.

Kaolin. Occurs in Cretaceous strata in Minnesota River valley; also in Itasca County. *See also* Clay (pottery).

Lignite. Itasca County, occurs in Rainy Lake region; of doubtful value.

Limestone (building). Cottonwood County, limestone was quarried at Selma and Delton for foundations and walls; Le Sueur County, magnesian limestone quarried at Kasota.

Limestone (crushed stone). Quarried in Anoka County, at Fridley; Blue Earth County, Judson and Mankato; Dakota County, Mendota, Farmington, and Lakeville; Dodge County, Mantorville; Fillmore County, Rushford; Goodhue County, Red Wing and Wanamingo; Hennepin County, Minneapolis; Houston County, Caledonia and Hokah; Le Sueur County, Kasota and Ottawa; Nicollet County, St. Peter; Olmsted County, Rochester; Ramsey County, St. Paul; Rice County, Cannon City; Scott County, Louisville; Sibley County, Faxon and Jessenland; Steele County, Clinton Falls near Owatonna; Traverse County, Austin; Wabash County, Minneiska; Washington County, Stillwater; Winona County, Minnesota City, Homer, Stockton, and Winona.

Limestone (hydraulic). Dodge County, Galena limestone at Mantorville, has properties of hydraulic limestone.

Limestone (lime). Limestones widely distributed and burned in many counties in the State.

Limonite. *See* Brown iron ore.

Magnetite (magnetic iron ore). St. Louis County, mined in Cuyuna, Mesabi, and Vermilion districts. Great quantities of lean magnetic iron-bearing rocks occur at east end of Mesabi Range, in Gunflint district, where Duluth gabbro cuts overlying formation.

Marl. Very frequently under the peat bog bordering many small lakes. Has been burned for lime.

Mica. Itasca County, occurs in pegmatite dikes in Rainy Lake region.

Mineral paint. Redwood County, kaolinized gneiss and granite was used for paint at Reedwood Falls.

Natural gas. Small quantities found in Big Stone, Freeborn, and Waseca counties; no importance.

Nickel. Cook County, small quantity in gabbro.

Peat. Anoka County, Coon Creek, formerly manufactured into fuel; many other localities.

Pyrite (auriferous). Has been mined in Cook County, at Pigeon Point, Lake Superior, with chalcopyrite; Itasca County, Rainy Lake region; St. Louis County, Vermilion Lake.

Quartzite. Pipestone County, quarried near Pipestone City. Occurs in Brown County at New Ulm, and in Cottonwood, Pipestone, Rock, and Watonwan counties; a very hard and durable stone.

Sand (building). Dug in Dakota County, at South St. Paul; Goodhue County, Red Wing; Hennepin County, Minneapolis; Nicollet County, Courtland; Rice County, near Northfield; Rock County, Luverne; St. Louis County, Lake Superior, near Duluth; Scott County, Jordan; Washington County, Stillwater; and Winona County, Winona.

Sand (concrete and mortar). Dakota County, St. Peter sandstone furnishes sand for mortar in several places; Fillmore County, St. Peter and Jordan sandstones suitable for mortar sand and lime, mixed for concrete at Fillmore and Rushford; Houston County, St. Peter and Cambrian sandstones quarried near Caledonia and Union.

Sand (molding). Dug in Pine County, at Kerrick; Ramsey County, St. Paul; Rice County, near Northfield; St. Louis County, Duluth; Washington County, Stillwater.

Sandstone (building). Pine County, quarried at Sandstone on Kettle River; fine quality.

Sandstone (concrete, crushed stone). Quarried in Brown County, at New Ulm; Chisago County, at Taylors Falls; Hennepin County, near Fort Snelling; Pine County, Banning; Pipestone County, Jasper; Rock County, Luverne; St. Louis County, near Fond du Lac; Scott County, Jordan along Sand Creek; Winona County, Dresbach.

Silver. Cook County, small quantity found in Animikie rocks.

Slate (roofing). Has been quarried in Carlton County, at Thomson; St. Louis County, few miles west of Duluth. In favorable situations and large quantity at Vermilion Lake and other points in northeastern Minnesota.

Specularite. *See* Hematite (specular iron ore).

Sphalerite (zinc blende). Itasca County, was mined in Rainy Lake region; Washington County, Stillwater. Small scattered masses at several places in "Trenton" limestone in southeastern Minnesota.

Trap rock. Quarried in Chisago County, at Taylors Falls; and St. Louis County, at Duluth.

Tripoli (polishing powder). Washington County, occurs at Stillwater between bluffs of Browns Creek.

MISSISSIPPI.

Brown iron ore (limonite). Tishomingo County, Iuka Lake, not used; common in orange sand but unimportant.

Burrstone. Attala, Carroll, Leake, and Neshoba counties furnish hard quartzitic sandstone used locally for building stone.

Cement material. Suitable material for Portland and natural cement is found in the northeastern part of the State, in Alcorn, eastern Chickasaw, Clay, Itawamba, Lee, western Lowndes, western Monroe, Noxubee, Oktibbeha, Prentiss, and Tishomingo counties; and in a belt extending nearly east and west across the center of the State, including parts of Clarke, Hinds, Jasper, Rankin, Scott, Smith, Warren, Wayne, and Yazoo counties; none produced.

Clay. Clay is found in nearly every county in the State. "Buckshot" clay burned and used as road metal at Clarksdale and elsewhere, Coahoma County.

Clay (brick). Brick is made locally from clay found in the following counties: Adams, Alcorn, Amite, Attala, Chickasaw, Claiborne, Clarke, Clay, Coahoma, Copiah, Covington, De Soto, Forest, Franklin, Greene, Grenada, Hancock, Harrison, Hinds, Holmes, Jackson, Jones, Lafayette, Lamar, Lauderdale, Lee, Leflore, Lincoln, Lowndes, Madison, Monroe, Montgomery, Newton, Noxubee, Oktibbeha, Panola, Pike, Pontotoc, Prentiss, Quitman, Smith, Sunflower, Tallahatchie, Tate, Tippah, Tunica, Union, Warren, Washington, Wayne, Webster, Wilkinson, Winston, Yalobusha, and Yazoo.

Clay (fire). Fire brick is made in Jefferson County at Stonington; Marshall County, Holly Springs; Smith County, Taylorville.

Clay (pottery). Pottery is made from the clays in Harrison County, at Biloxi; Itawamba County, at Miston and vicinity; Jefferson County, at Stonington; Lauderdale County, at Lockhart and Lauderdale; Marshall County, Holly Springs; Tishomingo County, Lake Coma; Webster County, Mathiston; Winston County, western part. Excellent clays for pottery, stoneware, and terra cotta abundant at Oxford, Lafayette County; not used at present.

Gypsum. Rankin County, near Cato; also east and west of Rankin County, was formerly mined. Gypsiferous marls in Attala, Carroll, Hinds, Holmes, Leake, Madison, Rankin, and Scott counties.

Lignite (brown coal). Found over a large part of the State. Of possible future importance in Benton, Calhoun, Choctaw, Holmes, Itawamba, Kemper, Lafayette, Lauderdale, Monroe, Panola, Pontotoc, Scott, Tate, Webster, Winston, and Yalobusha counties. No production at present. Thickest beds are 20 inches near Reedsville, Itawamba County, and two beds each 5 feet thick, separated by less than 2 feet of clay, at Tchula, Holmes County.

Limestone. Quarried for building material for local use in Clarke, Jasper, Noxubee, Smith, and Wayne counties. Burned for lime in Jasper, Rankin, and Wayne counties.

Limestone (hydraulic). *See* Cement material.

Limonite. *See* Brown iron ore.

Marl. Marls suitable for local use as fertilizer are found in Attala, Carroll, Chickasaw, Claiborne, Clarke, Hinds, Holmes, Leake, Lowndes, Madison, Pontotoc, Rankin, Scott, Smith, Tippah, Tishomingo, Warren, and Wayne counties.

Millstone. *See* Burrstone.

Ocher (mineral paint). Tishomingo County, extensive beds of red ocher, some yellow ocher near Iuka; was formerly mined and shipped.

Road metal. Burned clay used at Clarksdale, Coahoma County. Clay suitable for this use found throughout the Yazoo delta region. Crushed limestone from Tishomingo County used locally. Also chert gravel and beds of fine chert near Tennessee River in northeastern Tishomingo and in Itawamba counties. Other suitable material is burrstone of Attala, Clarke, Grenada, Lauderdale, Leake, Montgomery, Neshoba, and Newton counties.

Sand (building). Dug in Carroll County, at Carrollton; Forest County, at Hattiesburg; Hinds County, Jackson; Warren County, near Vicksburg; Washington County, Greenville. Immense quantity at Oxford, Lafayette County, and in most of the north-central counties where the Wilcox formation outcrops.

Sand (glass). Hinds County, occurs at Byram and Jackson, and elsewhere along Pearl River; Tishomingo County, large deposit of fine-grained silica 1 mile from Tennessee River now worked; also in southern part of county, Horn Island.

Sand (molding). Dug in Alcorn County, at Corinth; Hinds County, Jackson.

Sandstone. Attala, Carroll, Leake, and Neshoba counties, burrstone locally used; Claiborne County, sandstones of Grand Gulf region of inferior quality; Hinds County, has been quarried near Raymond; Lafayette, Marshall, Tippah, and Yalobusha counties, some stone suitable for building; Rankin County, quarried at Starr; Tishomingo County, along Big Bear Creek, Bay Spring, Gardner, on Rock Creek, and below Scott's mill.

Siderite. Notable deposits of iron carbonate have recently been discovered in Benton, Lafayette, Marshall, and Tippah counties.

MISSOURI.

Anglesite. Jasper County, Joplin district. In fine tabular crystals on galena in lead and zinc mines in southeast and southwest Missouri.

Asphalt (bitumen, mineral pitch). Barton County, occurs impregnating sandstone, and is quarried near Liberal; Lafayette County, in small quantity near Higginsville.

Azurite (blue carbonate of copper). Crawford, Dent, and Phelps counties, found in small quantities in many of the hematite deposits; Franklin County, at one time mined and smelted near Sullivan.

Barite (heavy spar). Cole County, mined at Eugene, Henley, and Hickory Hill; Franklin County, at Morrellton and St. Clair; Jefferson County; Miller County, at Etterville and Bagnell; Morgan County, at Versailles; St. Francois County, Blackwell; Washington County, Barytes, Cadet, Fertile, and elsewhere. Occurs as important gangue of central and southeastern lead regions.

Brown iron ore (limonite). Franklin County, mixed with ocher and chert in cavities at Bowlen Bank, Iron Hill, and Stanton Hill Bank, dug from pits near Moselle, and shipped; Howell County, Lamons mine, near West Plains, mined and shipped to lead smelters in Kansas City; Madison County, Mine La Motte, formerly used mainly for flux. Found chiefly in Cambrian limestones widely distributed over counties of the southern and central parts of the State; has been mined in numerous localities.

Calamine (silicate of zinc). Jasper County, mined in Joplin district; Lawrence County, at Aurora; Newton County, at Granby.

Calcite. Jasper County, occurs in Joplin district, museum specimens.

Cement (natural). Clinton County, shales and limestone suitable for natural cement in vicinity of Plattsburg.

Cement material (Portland). Ordovician and Devonian limestones and shales in narrow belt along eastern border of State from Ralls County on north to Cape Girardeau County on south. Mississippian limestones over extensive areas in northeast and southwest Missouri. Pennsylvanian ("Coal Measures") limestones and shales in northern and western parts of State best adapted for Portland cement. Plants at Cement City, east of Kansas City; Prospect Hill and Continental, near St. Louis; and Cape Girardeau.

Cerusite (carbonate of lead). Jasper County, mined in Joplin district; Newton County, Granby district; and in other mines in Dade, Greene, Lawrence, and Madison counties.

Chalcocite (copper glance). Occurs in subordinate quantity in Crawford County, in Sullivan mines; Shannon County, Slater and Tyrell mines near Eminence; Ste. Genevieve County, in Cornwall mines.

Chalcopyrite (copper pyrites). Franklin County, irregularly distributed through clay at Sullivan mine; Madison County, disseminated through limestone at Mine La Motte, and mined at Mine La Motte and Fredericktown; Shannon County, mined at Slater and Jerktail mines; Ste. Genevieve County, mined at

Ste. Genevieve mines. Widely distributed in small quantities in Joplin district, Jasper, Lawrence, and Newton counties.

lay (brick). Widely distributed and utilized in nearly every county of the State.

lay (brick shale). Barry County, numerous beds of shale at Golden City and elsewhere; Camden County; Cape Girardeau County, in Pennsylvanian ("Coal Measures") rocks near Jackson City; Clay County, extensive Pennsylvanian shale along Missouri River bluffs at Liberty Landing and Wayne City; Dade County, near Everton and Lockwood; Daviess County, near Gallatin and elsewhere along streams; Greene County, near Springfield and Willard; Iron County, near Belleview and Kaolin; Livingston County, several Pennsylvanian shale beds along streams; McDonald County, Sugar Creek and Mill Creek, in southern portion of county; Mercer County, near Princeton; Platte County, in Pennsylvanian rocks along river; Polk County, near Humansville; Ralls County, Louisiana to Hannibal along Mississippi River bluffs; Saline County, Slater, near Marshall, and elsewhere; Scott County, near Oran, and Benton; Shelby County, near Lakenan; St. Louis County, Prospect Hill and Cheltenham; Sullivan County, near Milan; Webster County, near Marshfield; Wright County, near Mansfield.

lay (fire). Mined in the following localities: Audrain County, at Mexico and Vandalia; Boone County, near Columbia; Callaway County, at Fulton; Crawford County, at Leasburg, flint clay; Franklin County, at Union and Washington; flint fire clays occur throughout the county; Gasconade County, at Canaan, Owensville, and Rosebud; Johnson County, at Knobnoster; Linn County, at Laclede; Montgomery County, at Jonesburg; Morgan County, at Versailles; Newton County, at Gregg; Shelby County, at Lakenan; St. Louis County, at Cheltenham and St. Louis; Stoddard County, near Dexter; Warren County, shipped from Truesdail and Pendleton.

lay (fire, flint). Boone County, occurs near Columbia; Crawford County, extensive deposits near Wesco; Franklin County, old pit near Washington; Maries County, excellent white in Lanes Prairie district; Monroe County, near Stoutsville, and Clapper; Montgomery County, mined at Jonesburg; Osage County, excellent quality abundant in central and southern part; Phelps County has been extensively worked at Knobview, Rolla, and St. James; St. Clair County, small deposits occur near Baker and elsewhere on Osage River; St. Louis County, near Glencoe, and elsewhere.

lay (fire, plastic). Monroe County, occurs in Pennsylvanian rocks covering nearly all of county; has been mined near Stoutsville for stoneware; Morgan County, excellent quality near Versailles; St. Charles County, has been mined near St. Charles.

lay (kaolin). Bollinger County, mined at Bollinger, extensive deposits near Glen Allen not worked in 1912; Cape Girardeau County, large deposit near Jackson; Morgan County, mined near Versailles; Warren County, mined at Warren.

lay (pottery). Cass County, dug near Harrisonville on Grand River; Cooper County, near Boonville; Franklin County, near Union; Henry County, Calhoun; Jasper County, near Webb City; Jefferson County, excellent ball clay mined at Regina; Johnson County, Knobnoster and Montserrat; Linn County, Kelsey and Laclede; Livingston County, near Chillicothe; Marion County, "pipe" clay on south side of New River, and elsewhere; Monroe County, abundant, mined at Stoutsville, and near Clapper; Ozark County, residual clay near Gainesville, mined to limited extent for local trade; Scott County, near Commerce, local use; Stoddard County, Dexter; Texas County, near Plato; Vernon County, near Deerfield. Pottery clay occurs in many other counties of the State.

Clay (shale, plastic). St. Louis County, from Pennsylvanian rocks, mined at Castello, Glencoe, and Prospect Hill.

Coal (bituminous). Coal found in the Des Moines group of the Pennsylvanian. Six producing fields: (1) Bevier field occupies parts of Boone, Chariton, Howard, Macon, and Randolph counties; (2) Lexington field in clay, Lafayette, and Ray counties; (3) Southwestern field in Barton, Bates, Henry, and adjacent counties; (4) Novinger field in Adair County; (5) Marceline field in Linn County; and (6) Mendota field in northwestern Adair, Putnam, and Schuyler.

Cobalt. Linnæite, sulphide of cobalt and nickel, associated with chalcopyrite and pyrite in some of the mines of the southeastern district especially Fredericktown, Madison County; recovered from the copper matte made in smelting these ores.

Copper. *See* Azurite, Chalcocite, Chalcopyrite, Cuprite, and Malachite.

Cuprite (copper oxide). Ste. Genevieve County, subordinate quantity in Cornwall mines, has been mined.

Feldspar. Camden and Laclede counties, in pegmatite granite on border line between counties; Ste. Genevieve County, in granite near Jonca, was used in Belleville pottery.

Fluorspar. Madison County, Einstein silver mine near Iron Mountain; St. Louis County, in St. Louis limestone near St. Louis.

Galena. Large production from disseminated deposits in southeastern district in Franklin, Jefferson, Madison, St. Francois, and Washington counties; associated with zinc in southwestern region, in Jasper, Lawrence, and Newton counties; and in central region in Cole, Miller, Moniteau, and Morgan counties.

Granite. Carter County, quarried in Van Buren; Iron County, extensively quarried at Graniteville; Madison County, Skrainka, and La Motte; St. Francois County, Syenite, and Knob Lick; Ste. Genevieve County; and Wayne County, Granite Bend.

Greenockite. Occurs with sphalerite in Joplin district, Jasper, Lawrence, and Newton counties.

Grindstone. Johnson County, sandstone at Warrensburg, has been used in the manufacture of grindstones; St. Clair County, few made at Collins and Griessel.

Hematite (red iron ore). Crawford County, in sandstone at Craig mine; Dent County, Flank, Hawkins, and Sligo mines; Franklin County, at Leslie mine; Phelps County, at De Camp; Reynolds County, good quality in sandstone on west limit of Bee Fork of Black River in January mine; and also in Callaway, Cooper, Henry, Lincoln, and Saline counties.

Hematite (specular ore). In porphyry, mined in Pilot Knob and Iron Mountain districts in St. Francois and Iron counties; in sandstone, has been mined in Crawford, Dent, Franklin, Iron, Montgomery, Phelps, and other counties.

Iron. *See* Brown iron ore, Hematite, and Marcasite.

Kaolin. Bollinger County, large deposits near Glen Allen, mined and shipped for pottery; Cape Girardeau County, pure white near Jackson, mined and shipped for paints, etc.; Morgan City, in Buffalo lead mines near Versailles, mined and shipped for enameling purposes. Occurs also in Carter County, at Chilton; Cooper County, Clifton City; Howell County, near West Plains and Sterling, and near Willard Springs; Iron County, in old pits and prospects at Kaolin, 12 miles west of Iron Mountain; Madison County, near Fredericktown; Oregon County, near Thayer; Perry County, near Silver Lake; Reynolds County, near Centerville, and Lesterville; Ripley County, near Doniphan; Shannon County, near Winona, and old pits near Monteer; Texas County, in vicinity of Sargent and Wayne County, near Brunot.

Limestone (building). Limestones widely distributed over the State suitable for building purposes. Large quarries in Cape Girardeau County; Greene County, Phenix; and Jasper County, at Carthage. Many other quarries in eastern, northern, and western counties of the State.

ad. *See* Anglesite, Cerusite, and Galena.

nestone (crushed stone, road metal, etc.). Quarried extensively throughout the State, with the exception of counties in the south-central part.

nestone (flux). Lincoln County, quarried at Ellsberry; and St. Louis County, near White House.

nestone (lime). Limestones excellent for lime making are burned at many localities in the State. Large plants are located at Ash Grove, Cape Girardeau, Glencoe, Glen Park, Hannibal, Louisiana, Mincke, Pierce City, Sarcoxie, Springfield, and Ste. Genevieve.

nonite. *See* Brown iron ore.

nneite (sulphide of nickel and cobalt). Occurs in mines of southeastern Missouri, in Madison County, at Mine La Motte and Fredericktown, and in St. Francois County.

lachite. Franklin County, mined near Sullivan; Shannon County, mined at Jerktail, Slater, and other mines; Ste. Genevieve County, at Cornwall mines. Occurs with azurite in many hematite deposits of Crawford, Dent, and Phelps counties.

nganese ore. Reported in porphyritic rocks around Pilot Knob, in Iron, Madison, and Reynolds counties.

rble. Occurs in Cape Girardeau, Iron, Madison, and other southeastern counties; not quarried.

rcasite. Franklin County, occurs in commercial quantity underneath hematite ores in central ore district, is mined at Leslie; Jasper County, occurs in abundance associated with lead and zinc ores in Joplin district, few carloads shipped.

neral paint. Iron ore, ferruginous shales, and limestones, lead ores and ocher are used.

tural gas. Cass, Clay, Clinton, and Jackson counties, small quantities in shallow wells.

ckel. Nickel and cobalt recovered from matte produced from ore from some of the mines of southeastern Missouri. *See also* Cobalt.

her. Henry County, common in the Pennsylvanian rocks of western part of the State, near Calhoun; Johnson County, Knobnoster, many exposures in this vicinity. A red ocher at Andrew County, Amazonia, and Jackson County, Hickman Mills. Others in Buchanan, Lafayette, and Ray counties. Produced to some extent in hematite mines of central Ozark County.

yx marble. Undeveloped commercial deposits in caves of Ozark region. Other localities in Atchison, Carroll, Daviess, Henry, Jackson, Lafayette, and Livingston counties.

troleum. Small quantity in shallow wells in northern Cass and southern Jackson counties.

rite (iron pyrites). Franklin County, Leslie mine, principal producer; Jasper County, occurs in Joplin district; Madison County, disseminated through limestone at Mine La Motte; St. Francois and Washington counties, gangue mineral of Federal, St. Louis, and other mines. *See also* Marcasite.

ad metal. Andrew County, oolitic limestone was quarried at Schuster station; Clay County, Bethany Falls limestone was quarried near Liberty. *See also* Limestone (crushed) and Sandstone (crushed).

Limestone quarried at Andrew County, Amazonia; Daviess County, Gallatin; Jackson County, Kansas City, Independence, and other places; St. Louis County, St. Louis, and other places. Granite and porphyry quarried in Iron, Madison, and St. Francois counties.

Sand (building). Inexhaustible supply can be dredged from Missouri and Mississippi rivers and their tributaries. Atchison County, dug at Rockport; Benton County, Warsaw; Buchanan County, St. Joseph; Callaway County, near Fulton; Carroll County, Carrollton; Christian County, Ozark; Cole County, Jefferson City; Cooper County, Boonville; Daviess County, Gallatin; Franklin County, Pacific; Gasconade County, Drake; Grundy County, Trenton; Jackson County, Kansas City; Jefferson County, Crystal City; Marion County, Hannibal; Phelps County, Jerome; St. Charles County, Klondike and St. Charles.

Sand (glass). St. Peter sandstone between Klondike, on Missouri River, and Crystal City, on Mississippi River. Important quarries in Atchison County, at Rockport; Franklin County, Becker, Gray Summit, and Pacific; Jefferson County, Crystal City and Silica; and St. Charles County, at Klondike.

Sand (molding). Number of small pits in Franklin County, at Gray Summit and Pacific; Kent County, Black Hills; St. Charles County, Klondike.

Sandstone (building, monuments, crushed stone, etc.). Barton County, quarried near Lamar and Liberty; Bates County, Butler and Rich Hill; Benton County, near Cole Camp; Carroll County, DeWitt and near Miami station; Clark County, near Kahoka, local use; Franklin County, near Union; Henry County, near Clinton; Johnson County, near Warrensburg; Saline County, near Miami; St. Clair County, near Collins. Bituminous sandstone quarried in Lafayette County, near Higginsville.

Silver. Recovered from the lead ores of southeastern Missouri in Jefferson, Madison, St. Francois, and Washington counties.

Smithsonite (carbonate of zinc). Jasper County, in quantity in many mines of the Joplin district; Newton County, at Granby; St. Francois County, principal zinc ore at Valle mines; occurs also in central district in Cole, Miller, Moniteau, and Morgan counties, and mined in Howell and Oregon counties.

Specularite. *See* Hematite (specular ore).

Sphalerite (zinc blende). Principal ore of the Joplin district, Jasper, Lawrence, and Newton counties; mined also in central district, Cole, Miller, Moniteau, and Morgan counties; has been mined at Frumet and at Valle mines, Jefferson County; occurs also in small quantity in the deeper disseminated lead ores of Madison and St. Francois counties.

Tripoli (polishing powder). Chariton County, quarried extensively at Dalton; Jefferson County, occurs at Hillsboro; Newton County, quarried extensively near Racine and Seneca, for filters; chips and waste used for polishing powder and scouring soap; occurs at Stella.

Wad. Found in connection with brown iron ore deposits in southeastern Missouri.

Zinc. Chief production from mines in Jasper County, about Alba, Carterville, Carthage, Duenweg, Joplin, Neck, Reeds, Sarcoxie, Thoms Station, and Webb City; Lawrence County, Aurora; Newton County, Granby, Spurgeon, and Wentworth. *See also* Calamine, Smithsonite, and Sphalerite.

MONTANA.

Ægirite. Lincoln County, vanadiferous ægirite occurs in quartz veins associated with sulphides of iron and copper in the Rainy Creek district, 4 miles southwest of Libby.

Agate, moss. Found along Yellowstone River, especially near Glendive.

Antimony. *See* Polybasite and Stibnite.

Argentite (silver glance). Cascade County, in Neihart district; Deer Lodge County, at Cable mine; Granite County, Granite-Bimetallic mine, Philipsburg; Jefferson County, Ruby mine, Boulder and Clancey; Silver Bow County, Butte mines.

Arsenic. Smelter by-product saved at the Washoe smelter, Anaconda, in smelting arsenical copper ores.

Arsenopyrite. Deer Lodge County, in Cable mine; Granite County, Granite-Bimetallic mine, Philipsburg, mined for silver and gold; Jefferson County, Corbin, Elkhorn, Warm Spring Creek, and Wickes (auriferous); Missoula County, Mineral Point mines, silver bearing; Powell County, Elliston; Lewis and Clark County, Tenmile district, formerly mined for gold contents near Gardiner, Sheep-eater mining district; Park County, abundant, massive, and gold bearing; not mined.

Azurite (blue carbonate of copper). Of mineralogic rather than economic interest. Found in small quantity in many mines and prospects; Deer Lodge County, Cable mine; Granite County, Granite-Bimetallic mine near Philipsburg; Jefferson County, in minute clusters in Elkhorn mine and in McClellan Creek district; Lewis and Clark County, Drumlummon mine, Marysville; and Silverbow County, Butte district.

Bentonite. Beaverhead County, near Glendale.

Bornite (peacock ore). Deer Lodge County, in small quantity at Cable mine, carries gold; Granite County, at Granite-Bimetallic mine; Jefferson County, Corbin; Silver Bow County, common ore mineral, Butte district.

Brown iron ore (limonite). Cascade and Meagher counties, found at a number of localities in Little Belt Mountain district; Chouteau County, occurs in oxidized ores of gold deposits near Landusky and Alabama; Deer Lodge County, at Cable mine; Fergus County, formerly mined in Judith Mountains, prospected at Woodhurst Mountain and in Little Belt Mountains; Jefferson County, at many places in Elkhorn and Wickes districts, mined at Elkhorn Peak iron mine.

Cement material. Chouteau County, suitable materials known to exist at Havre; Gallatin County, limestone and shale quarried for Portland cement at Trident; suitable material at other places but not used.

Cerargyrite (horn silver). Granite County, was important ore of Granite mine, 2½ miles southeast of Philipsburg; Silver Bow County, found in small quantity in Summit Valley (Butte) district and other mining districts.

Cerussite (lead carbonate). Jefferson County, has been mined in Elkhorn and Wickes districts; Meagher County, Castle Mountain district. Occurs in many other districts.

Chalcanthite (copper sulphate). Silver Bow County, minor ore of oxidized zone, Butte district.

Chalcocite (copper glance). Deer Lodge County, in small quantities at Cable mine; Silver Bow County, important ore of Butte mines. Occurs in many other districts.

Chalcopyrite (copper pyrite). Broadwater County, has been found in Beaver Creek and Crow Creek districts; Deer Lodge County, Cable mine carries gold; Granite County, Philipsburg; Jefferson County, with pyrite in Amazon, Clancey, Corbin, Elkhorn, McClellan Creek, Rimini, Warm Spring Creek, and Wickes districts; Lewis and Clark County, Drumlummon mine, Marysville (rare); Lincoln County, Troy, Grouse Mountain prospects carry silver and gold; Park County, abundant with galena, New World district near Cooke City and at many other places; Ravalli County, Mineral Point, silver and gold bearing; Silver Bow County, minor ore in silver veins at Butte.

Chrysocolla (silicate of copper). Deer Lodge County, occurs in Cable mine; Granite County, Granite-Bimetallic mine near Philipsburg; Silver Bow County, in claims east of Butte along the foothills of East Ridge.

Clay (brick). Can be found abundantly throughout the State. Beaverhead County, dug at Dillon; Cascade County, Great Falls; Chouteau County, Havre; Custer County, Miles City; Flathead County, Kalispell and Whitefish; Gallatin County, Bozeman; Jefferson County, Boulder; Lewis and Clark County, Helena; Missoula County, South Missoula and Riddle Spur; Park County, Livingston; Powell County, Blossburg; Ravalli County, Stevensville; Rosebud County, Forsyth; Sanders County, Thompson; Silver Bow County, Butte and Williamsburg; Valley County, Glasgow; and Yellowstone County, Columbus.

Clay (fire). Cascade County, dug near Armington and at Fields; Deer Lodge County, Anaconda and Lost Creek; Jefferson County, Whitehall; Lewis and Clark County, Helena.

Coal (bituminous and subbituminous). Areas of workable coal are known to exist in the following counties: Carbon, Cascade, Chouteau, Fergus, Flathead, Gallatin, Madison, Missoula, Musselshell, Park, Rosebud, Teton, and Yellowstone. Coal is mined in the following places: Carbon County, Bear Creek, Bridger, Burgin, Carbon, Fromberg, Joliet, Red Lodge, and Washoe; Cascade County, Armington, Belt, Eden, Geyser, Sand Coulee, and Stockett; Chouteau County (Big Sandy), Chinook, Harlem, Havre, and Macton; Fergus County, Buffalo Creek, Giltedge, Lewiston, Stanford, Smith, Utica, and Windham; Gallatin County, Chestnut; Missoula County, Missoula; Musselshell County, Roundup; Park County, Cinnabar and Cokedale; Yellowstone County, Bull Mountains.

Coal (lignite). Areas of workable lignite are known to exist in Custer, Dawson, Rosebud, and Valley counties. Custer County, mined at Miles City and Stacey; Dawson County, Cohagen, Jordan, Glendive, and Wibaux; Valley County, Brockton and Culbertson; chiefly for local use.

Copper ores. *See also* Azurite, Bornite, Chalcocite, Chalcanthite, Chalcopyrite, Chrysocolla, Covellite, Cuprite, Enargite, Malachite, and Tetrahedrite. Copper is the predominant metal produced in the following districts: Beaverhead County, Beaverhead, Elkhorn, Utopia; Broadwater County, Hellgate; Meagher County, Copperopolis; Missoula County, Denemora, Wallace; Ravalli County, Mineral Point; Silver Bow County, Butte.

Copper (native). Deer Lodge County, small quantities in upper level of Cable mine at Cable; Silver Bow County, in oxidized zone of Butte.

Corundum. Gallatin County, was formerly mined at Bozeman, Salesville, and headwaters of Elk Creek for abrasive. No abrasive corundum is now mined in Montana.

Corundum (sapphire). Deer Lodge County, in gravel of Dry Cottonwood Creek; Fergus County, in dike near Yogo Gulch (blue gems only); Granite County, considerable quantity mined from placers on Rock Creek, 20 miles southwest of Philipsburg; Lewis and Clark County, mined in placers of Missouri River, east and northeast of Helena.

Covellite (indigo copper). Jefferson County, Boulder (rare); Silver Bow County, ore of minor importance in Butte mines.

Cuprite (red copper oxide). Silver Bow County, minor mineral in ore of Butte district.

Enargite. Silver Bow County, next to chalcocite, the most abundant copper mineral at Butte.

Galena (argentiferous). Beaverhead County, mined in Hecla and Trapper districts; Broadwater County, Argenta, Beaver Creek, Crow Creek, Indian Creek, Park, and Winston districts; Cascade County, Barker and Neihart districts; Chouteau County, Bearpaw Mountains; Deer Lodge County, Cable district (rare); Granite County, Philipsburg; Jefferson County, Amazon, Basin, Clancey, Elkhorn, Gregory, Lump Gulch, and Wickes districts; Lewis and Clark County, Bald Butte, Helena, Ottawa, Rimini, and Tenmile districts; Lincoln County, Troy, and Snowshoe; Meagher County, Castle Mountain; Missoula County, Iron Mountain; Park County, New World; Powell County, Elliston; Ravalli County, Hamilton (Curlew mine); Silver Bow County, sparingly in silver veins and in some of the later fault veins of the copper area, Butte.

Garnet. Madison County, small quantity recovered from gold dredges at Alder Gulch and at Ruby; cut for jewelry.

Gold (lode). Widely distributed in southwestern quarter of the State. Principal districts that have produced are: Beaverhead County, Bald Mountain and Bannock; Broadwater County, Lone Mountain, Park, and Radersburg; Chouteau County, Landusky and Bearpaw; Deer Lodge County, Cable and Heber; Granite County, Philipsburg and Red Iron; Jefferson County, Cataract, Colorado, and Lump Gulch; Lewis and Clark County, Bald Butte, Helena, Marysville, and Rimini; Lincoln County, Cabinet, Fisher Creek, and Sylvanite; Madison County, Pony, Norris, and Whitehall; Missoula County, Clinton and St. Regis; Silver Bow County, Fleecer Mountain, German Gulch, and Highland.

Gold (placer). Placer mining formerly very important, still carried on to some extent in Broadwater, Chouteau, Deer Lodge, Granite, Jefferson, Lewis and Clark, Lincoln, Madison, Missoula, Park, Powell, Ravalli, and Silverbow counties. Formerly in Beaverhead, Custer, and Meagher counties as well. Beaverhead County, dredged near Dillon; Deer Lodge County, dredged near Deer Lodge; Madison County, dredged in Alder Gulch; Missoula County, dredged in Cedar Creek.

Gold tellurides. Fergus County, formerly mined in Judith Mountains, Spotted Horse mine.

Granite. Abundant in western part of the State. Jefferson County, quarried at Welch and near Corbin; Lewis and Clark County, quarried at Baxendal, near Helena, also at Helena.

Graphite. Beaverhead County, mined near Dillon.

Grindstone. Yellowstone County, produced at Columbus.

Gypsum. Widely distributed throughout eastern flanks of the Rocky Mountains. Cascade County, mills located at Armington and Riceville; Carbon County, Bridger, on local deposits; Jefferson County, quarried near Limespur; Park County, occurs at Hunters Hotsprings.

Hematite (red iron ore). Deer Lodge County, found in Cable mine; Jefferson County, with magnetite, in mine on north side of Elkhorn Peak, Elkhorn district.

Hematite (specularite, turgite). Deer Lodge County, found at Cable mine, carrying gold; Granite County, mined for flux near Philipsburg. Occurs at many localities in Little Belt Mountains district, Cascade, Fergus, and Meagher counties, and prospected at Woodhurst Mountain; in small quantities at other places.

Hübnerite. Granite County, occurs at Philipsburg; Madison County, with silver ore in Potosi district, 8 miles southwest of Pony; Powell County, occurs at Sugarloaf Mountain; Silver Bow County, Birdie silver mine, and Gagnon and Leonard mines, Butte, small quantities mined.

Lead. *See* Cerusite, Galena, and Pyromorphite.

Lignite. *See* Coal.

Limestone (building). Abundant in western part of the State. Quarried in Flathead County, at Kalispell; and Lewis and Clark County, Helena.

Limestone (flux and lime). Cascade County, quarried at Albright and Logging Creek; Gallatin County, Bozeman; Jefferson County, Limespur; Lewis and Clark County, East Helena; Powell County, Elliston; and Silver Bow County, Divide.

Limonite. *See* Brown iron ore.

Magnetite. Chouteau County, with apatite and augite in Black Diamond prospect, Bearpaw Mountains, high grade, not mined; Deer Lodge County, was formerly mined for flux at Cable mine; Gallatin County, near Bozeman; Jefferson County, formerly mined with hematite in iron ores on Elkhorn Peak.

Malachite. Chouteau County, found in small quantities in gold-bearing veins near Landusky; Deer Lodge County, at Cable mine; Granite County, Granite-Bimetallic mine near Philipsburg; Jefferson County, small quantities in Elkhorn mine and McClellan Creek district; Silver Bow County, Butte district; and in many other places. Of more mineralogic than economic interest.

Manganese ore. Cascade County, manganiferous silver ore mined at Neihart; Deer Lodge County, carries gold and silver at Cable mine; Granite County, was mined in Granite-Bimetallic mine near Philipsburg; Madison County, prospected on Wigwam and Cherry creeks, 15 miles southeast of Virginia City; Silver Bow County, oxidized ore of Butte mines, silver bearing.

Marcasite. Deer Lodge County, carries gold at Cable mine; Lincoln County, found in Troy, Grouse Mountain prospects; Silver Bow County, common in Butte mines.

Molybdenite. Beaverhead County, occurs in quartz veins near Dillon; Fergus County, at Neihart; Jefferson County, at Homestake.

Monazite. Granite County, has been found in black sands at Princeton; Madison County, at Norris; Powell County, locality not reported.

Petroleum. Teton County, in northwest part; no production.

Phosphate. Granite County, good bed at Philipsburg; Madison County, thin beds in canyon of Jefferson River between Limespur and Cardwell; Powell County, good bed near Elliston, and 6 miles north of Garrison; Silver Bow County, Melrose; and elsewhere.

Pisanite. Silver Bow County, common in old drifts in Butte copper mines.

Platinum. Granite County, small quantity in black sands at Princeton, not mined.

Polybasite. Cascade County, intimately associated with galena and sphalerite in Neihart district; Lewis and Clark County, rich in silver, Drumlummon mine, Marysville.

Proustite. Granite County, sparingly scattered through ore in Granite-Bimetallic mine, Philipsburg.

Psilomelane. Silver Bow County, at Butte, common surface ore in many veins, usually contains silver.

Pyrargyrite (ruby silver). Cascade County, common in Neihart district, usually associated with polybasite; Deer Lodge County, known but not now mined; Granite County, Granite-Bimetallic mine near Philipsburg, with galena and sphalerite; Lewis and Clark County, Drumlummon mine, Marysville.

Pyrite. Common ore of gold, has been mined in the following districts: Broadwater County, Beaver Creek, Crow Creek, Indian Creek, Radersburg; Cascade County, Neihart; Chouteau County, Landusky, Alabama; Deer Lodge County, Cable; Fergus County, Ford Creek, Gilt Edge, Maiden; Granite County, Philipsburg; Jefferson County, near Basin, Boulder, Clancey, Elkhorn, Gregory, and Warm Spring Creek; Lewis and Clark County, Bald Butte; Lincoln County, Sylvanite; Madison County, Pony; Missoula County, Mineral Point, Mineral Hill; Powell County, Elliston; Silver Bow County, Butte (cupriferous).

Pyrolusite (black oxide of manganese). Chouteau County, with high-grade gold ores in mines near Landusky and Alabama; Granite County, mined for flux in Flint Creek (Philipsburg) district; Meagher County, large veins at Castle, carry small quantity of lead; Silver Bow County, common surface ore in many veins at Butte carrying rhodonite, etc.; usually contains silver, and is much sought for as flux for siliceous ores.

Pyromorphite (phosphate of lead). Cascade County, found in one mine in Narrow Gauge Gulch, Neihart district; Granite County, in Granite-Bimetallic mine, near Philipsburg.

Pyrrhotite (magnetic pyrites). Chouteau County, found in Bearpaw Mountains; Deer Lodge County, at Cable mine, carries gold; Jefferson County, Elkhorn district.

Rhodonite (manganese silicate). Silver Bow County, gangue mineral of silver veins of Butte mines; cut as gem.

Sand (building). Dug at many places for local use.

Sandstone. Sandstone suitable for dimension stone is abundant. Cascade County, quarries at Field and Great Falls; Gallatin County, Salesville and Sappington, near Bozeman; Park County, Livingston; Yellowstone County, Billings and Columbus.

Sapphire. *See* Corundum.

Scheelite. Park County, has been mined at Jardine with gold.

Silver (native). Cascade County, in oxidized veins in Neihart district; Granite County, in upper levels of Granite-Bimetallic mine, Philipsburg; Jefferson County, at Clancey, Elkhorn, and Ruby mines; Silver Bow County, common in silver veins and oxidized portions of copper veins at Butte.

Silver. Predominant metal value in following districts: Beaverhead County, Dillon, Hecla, and Vipond; Cascade County, Neihart; Jefferson County, Elkhorn; Lewis and Clark County, Greenhorn; Park County, Cowles. *See also* Argentite, Cerargyrite, Polybasite, Proustite, Pyrargyrite, and Stephanite.

Sphalerite (zinc blende). Broadwater County, mined in Beaver Creek district; Cascade County, occurs with galena in all veins in Neihart district; Deer Lodge County, rare at Cable; Granite County, in all silver-gold fissure veins near Philipsburg; Jefferson County, with galena and pyrite and lesser quantities with tetrahedrite in galena ores of Basin, Boulder, Clancey, Elkhorn, Gregory, and Lump Gulch districts; Lewis and Clark County, with galena in Bald Butte, Helena, and Rimini; Lincoln County, Cullahan Creek and Troy; Missoula County, Iron Mountain; Powell County, Elliston; Silver Bow County, common in Butte mines.

Spinel (pleonaste). Madison County, between South Meadows and Moore creeks not mined.

Stephanite (brittle silver). Cascade County, rare in Neihart district.

Stibnite (sulphide of antimony). Granite County, abundant in primary ore of silver veins near Philipsburg.

Tennantite. Granite County, in lower portions of Granite-Bimetallic mine, Philipsburg; Silver Bow County, occurs sparingly associated with enargite in copper veins at Butte.

Tetradymite. Broadwater County, with gold and silver in Keating mine, Radersburg.

Tetrahedrite (gray copper ore). Granite County, Flint Creek district, with galena and sphalerite, argentiferous, was formerly mined, abundant in lower levels, Granite-Bimetallic mine; Jefferson County, with sphalerite in Elkhorn mine, argentiferous; also at Basin and Clancey; Lewis and Clark County, formerly mined at Drumlummon mine, Marysville; Missoula County, Pleasant View and Slate Creek prospects, carries gold and silver; Silver Bow County, ore of minor importance in Butte mines in copper and silver veins.

Thorianite. Madison County, known at Norris, not mined.

Vanadinite. Beaverhead County, reported 27 miles northwest of Dillon in Rothschild mine.

Volcanic ash. Gallatin County, deposits suitable for use as polishing powder in vicinity of Bozeman, and in Meagher County, at Castle Mountain.

Wad. Jefferson County, with limonite in granite about 6 miles north of Wickes station, not mined; Silver Bow County, with silver ores of Butte district.

Wurtzite. Silver Bow County, Gagnon mine, Butte.

NEBRASKA.

Abrasive. *See* Infusorial earth and Pumice.

Agate (moss). Agate, Keith, Scotts Bluff, and Sioux counties; cut for jewelry.

Cement material. Carboniferous limestone and shale, suitable for cement material, outcrop in southeastern part of State in Cass, Douglas, Gage, Johnson, Lancaster, Nemaha, Otoe, Pawnee, Richardson, and Sarpy counties; not utilized. Cement formerly made from Carboniferous rock at Beatrice, Gage County. Cretaceous chalk rock and underlying shales, suited to the manufacture of cement, outcrop extensively in northeastern Nebraska along Niobrara and Missouri rivers in the following counties: Eastern Boyd, Cedar, Dixon, Dakota, and northern Knox. Likewise, along the southern line of Nebraska in the Republican Valley, in the following counties: Franklin, Nuckolls, southern Harlan, and Webster. The cement material of the Cretaceous in Nebraska belongs essentially to the Niobrara formation, although a chalky layer (Inoceramus zone) about 20 feet thick constitutes the upper part of the Greenhorn limestone. A large plant is at Superior, Nuckolls County.

Chalcedony. Gage County, common vein filling in the Badlands.

Chalk rock. The Greenhorn limestone at Hebron, Thayer County, and the Niobrara formation of Knox County, notably at the town of Niobrara, furnish considerable quantities of building material. The chalk rock of these formations is soft enough to be sawed into blocks when "green" (fresh from the quarry); on drying, it becomes harder and has good lasting qualities. The chalky Greenhorn rock of Endicott, Jefferson County, and at Pleasant Hill, Saline County, used to be burned into lime for local consumption.

Clay (brick). Brick and tile made in the following counties: Adams, Antelope, Box Butte, Boyd, Buffalo, Burt, Butler, Cass, Cedar, Clay, Cuming, Dixon, Dodge, Douglas, Fillmore, Furnace, Gage, Greeley, Hall, Hamilton, Howard, Jefferson, Kearney, Knox, Lancaster, Loup, Madison, Nance, Nemaha, Nuckolls, Otoe, Pawnee, Phelps, Platte, Polk, Redwillow, Richardson, Saline, Saunders, Scotts Bluff, Seward, Sherman, Stanton, Thayer, Washington, Wayne, Webster, and York.

Clay (fire). Occurs in Pennsylvanian ("Coal Measures") in southeastern part of State.

Clay (loess). In many parts of the State large quantities of ordinary building and hollow brick are made from loess, which in many cases is very poor in clay.

Clay (pottery). Cass County, has been dug at Louisville; Jefferson County, coarse pottery clay at Endicott; Washington County and elsewhere in southeastern Nebraska.

Coal (bituminous). Cass, Johnson, and Otoe counties; Nuckolls bed 8 to 18 inches thick, worked for local use. Nemaha County, working mine at Honey Creek 4 miles south of Peru in bed 33 inches thick; Otoe County, bed 15 inches thick in a boring at Nebraska City; Pawnee County, beds at Du Bois, Friezes Mill, and Turners Branch worked intermittently; Richardson County, has been mined at Rulo, and a bed 18 to 30 inches thick has been opened and worked for local use in southwest corner of county.

Coal (lignite). Dakota County, mined for local use near Homer; and Dixon County, in bluffs near Ponca.

Flint. Gage County, quarried and crushed for ballast at Blue Springs and Wymore.

Gold (placer). Occurs in sands of Platte River and in glacial drift; of no importance.

Halite (common salt). Previous to development of Kansas salt beds salt was made in considerable quantity in southeastern Nebraska from water of salt springs and deep wells. No longer produced, but artesian flow of salt water is used at Lincoln in sulpho-saline baths.

Infusorial earth. Greeley County, best beds in this county; Thomas County, deposit of several acres near Thedford; Wheeler County, number of beds on Cedar Creek; occurs in Blaine, Hooker, and other counties. Small quantity formerly sold for polishing powder.

Limestone (building). Cass County, quarries located at Nehawka, Cedar Creek, Louisville, and Weeping Water; Gage County, Wymore and Blue Springs; Jefferson County, near Fairbury and Endicott; Johnson County, Graf and Tecumseh; Nemaha County, Auburn and Glen Rock; Otoe County, Syracuse and Nebraska City; Sarpy County, La Platte and Meadow; Cheyenne County, Sidney; small quarries at other localities.

Limestone (crushed stone). Cass County, quarried at Cedar Creek, Louisville, and elsewhere; Cheyenne County, Sidney; Gage County, Holmesville, Rockford, and Wymore; Nemaha County, Auburn, Brock, and Johnson.

Limestone (flux). Cass County, quarried at Nehawka.

Lithographic stone. Otoe County, occurs near Syracuse; has not proved of commercial quality.

Ocher. Known in many places in northeastern counties on Platte River and along Republican River; was mined at Indianola, Redwillow County.

Peat. Widely distributed. On Loups Rivers and on their tributaries; on the Logan; along tributaries at headwaters of Elkhorn, Blue, and Stinking rivers; not utilized.

Pumice. Produced in Furnas County; Harlan County, Orleans; Holt County, Atkinson; Jefferson County, Endicott; Lincoln County, Ingham; and in other counties; used as an abrasive.

Road metal. Cass County, gravel in Platte Valley and in glacial drifts; pits near Louisville; Gage County, large supply of flint, quarried in vicinity of Wymore and Blue Springs.

Sand (building). Principal pits are at the following places: Antelope County, Oakville; Buffalo County, Ravenna, Kearney; Burt County, Tehameh; Cass County, Cedar Creek, Louisville; Cedar County, Hartington; Colfax County, Schuyler; Custer County, Ansley, Mason City, Sargent; Douglas County, Omaha, Valley; Dodge County, Fremont; Fillmore County, Geneva; Gage County, Beatrice; Hall County, Grand Island; Platte County, Lindsay; Polk County, Atkinson; Richardson County, Falls City, Salem; Sarpy County, Meadow; Saunders County, Ashland. Many small pits widely scattered through State. Dredges taking sand from lower Platte at Ashland, Cedar Creek, Louisville, Fremont, Meadow, Valley, and Oreapolis. Forty sand-shipping stations in State produced in one year 40,000 cars, equal to train over 300 miles long. Cass County is largest producer.

Sand (molding). Adams County, dug at Erickton.

Sand and gravel. Pits supplying local demand are widely distributed; Cass County, large production from Cedar Creek; Jefferson County, dug 2 miles west of Fairbury; shipped for cement, plastering, etc., also dug near Kesterson and elsewhere.

Sandstone. Cass County, quarried at Louisville; Cherry County, occurs at Valentine; Dawes County, Chadron; Nemaha County, Brownville.

Turquoise. Brown County, three stones, probably variety known as Odontolite, have been found.

NEVADA.

Alum (kalinite). Esmeralda County, prospected by roadside about 10 miles north of Silver Peak.

Alunite. Esmeralda and Nye counties, abundant in volcanic rocks and with ores in Goldfield district, not utilized.

Anglesite (sulphate of lead). Eureka County, important mineral in oxidized ores at Ruby Hill and in Eureka district, silver bearing; Clark County, mined with oxidized zinc ores at Goodsprings.

Annabergite. Humboldt County, important constituent of ore at Lovelock nickel mine, Cottonwood Canyon, Pahute Range.

Antimony. *See* Jamesonite, Stibiconite, and Stibnite.

Argentite (silver glance). Elko County, at Columbia; Humboldt County, at Rosebud; Lander County, at Cortez; Nye County, important silver mineral of Tonopah district; White Pine County, Cherry Creek district.

Arsenic. Washoe County, native arsenic, in considerable quantity, occurs at a prospect a few miles south of Pyramid Lake.

Arsenopyrite. Elko County, silver ore at Tuscarora; Eureka County, Ruby Hill, Eureka district; Humboldt County, with pyrite and quartz at Auld Lang Syne mine near Chafey; Washoe County, with lead and zinc ore at Galena.

Asphalt. Eureka County, stringers and lenses up to 18 inches wide filling fractures in Carboniferous rocks 15 miles south of Palisade.

Azurite. Elko County, with silver ore in Mountain City; Esmeralda County, sparingly in Goldfield district, Montezuma and Cuprite mines; Eureka County, small quantity at Ruby Hill, Eureka district, and in Mineral Hill district; Humboldt County, small quantity in Red Butte copper district and Lovelocks cobalt-nickel mine in Cottonwood Canyon, Pahute Range; Lyon County, in Mason Valley mine, Yerington copper district, and other localities.

Barite. Ormsby County, mined at Barium mine; Elko, Eureka, and Lander counties, gangue mineral in many veins; Esmeralda County, abundant with ore in Sandstorm and Kendall mines, Goldfield district; Humboldt County, a common gangue mineral in Humboldt Range.

Bindheimite. Esmeralda County, 15 miles east of Thorne.

Bismuth (native). Clark County, with bismutite near Sandv; Mineral County, with bismite near Candelaria.

Bismuthinite. Esmeralda County, with rich gold ore at Goldfield.

Borax. Deposits of the marsh type were formerly extensively worked in Churchill County, in Salt Wells Valley; Esmeralda County, at Teals, Rhodes, and Columbus marshes, and Fish Lake Valley. Borax was also made from hot spring waters in Churchill County, east of Wadsworth; Washoe County, at Gerlach.

Bornite. Elko County, secondary ore in Tuscarora mines; Humboldt County, with chalcopyrite at Mazuma Hills mine, Seven Troughs district; Lander County, mined for gold and silver at Tenabo.

Bromyrite. Elko County, silver ore in Mountain City, mined at Protection mine; Eureka County, Silver Hill and in quartz at Caribou Hill, Eureka district.

Brown iron ore (limonite). Not mined as an ore of iron, but occurs abundantly in the oxidized portions of deposits worked for other metals and may carry gold and silver, as in the following districts: Esmeralda County, Cuprite and Goldfield districts, Old Camp, Gold Mountains district; Eureka County, carries free gold, principal component of Ruby Hill ores; Humboldt County, with argentite at Brown Palace mine, Rosebud district; Lander County, Mud Springs 4 miles north of Lander; Lyon County, Mason Valley mine, Yerington district, also with hematite and magnetite near Dayton; Nye County, Bullfrog and Silverbow districts.

Calamine (zinc silicate). Clark County, mined with other zinc ores at Goodsprings; Eureka County, in fine crystals with limonite at Ruby Hill, Eureka district.

Cement material. Carboniferous limestone outcrops in east third of State; suitable for Portland cement; not used. Ormsby County, large bodies of limestone in shale several miles east of Carson City, analyses show that suitable mixture would make good cement.

Cerargyrite (horn silver). Elko County, secondary mineral in Gold Circle district; Esmeralda County, abundant in quartz at Great Western mine, Hornsilver district; in oxidized ore near Diamondfield, Goldfield district; Humboldt County, Durango Girl mine, Rosebud district; Nye County, principal mineral of Bullfrog district, formerly mined at Montgomery-Shoshone mine; secondary mineral at Silverbow and Eden.

Cerusite (carbonate of lead). Clark County, mined at Potosi and other mines, Goodsprings district; Elko County, silver ore in Mountain City, mined at Protection mine; Esmeralda County, Redemption mine near Hornsilver; Lone Mountain mines, South Klondike, and Montezuma; mined for silver; Eureka County, Ruby Hill, Eureka district; worked for silver at Mineral Hill; Humboldt County, mined for silver at Fairmont and Beaconsfield mines, Winnemucca district; Lander County, Mud Springs 4 miles north of Lander; Lincoln County, Potosi mine; White Pine County, has been mined in Ely (Robinson) district.

Chalcanthite. Lyon County, Bluestone mine, Yerington copper district. Formerly mined for use in amalgamating Comstock ores.

Chalcedony. Occurs in Esmeralda County, at Aurora; Mineral County, 2 miles southeast of Redlich; Nye County, Gold Mountain district between Tonopah and Klondike.

Chalcocite (copper glance). Elko County, important ore in Bullion district, Standing Elk principal mine; Esmeralda County, argentiferous in mines of Cuprite and Montezuma districts; Humboldt County, in a vein in gabbro at Red Butte; Lander County, mined for gold in Tenabo district; Lyon County, Yerington mine, Yerington copper district in small quantity; Nye County, sparingly in Original Bullfrog mine in Bullfrog district, with free gold; Ormsby County, at numerous localities, carries gold and silver; White Pine County, important ore in Ely district.

Chalcopyrite (copper pyrite). Clark County, with platinum in Copper King district; Elko County, important gold and silver ore at Big Four, Columbia, Jack Pot, and other mines; Esmeralda County, mined at Montezuma, carries silver; Eureka County, important silver ore at Mineral Hill, and in small mines and prospects in Safford district; Humboldt County, Adelaide mine, Seven Troughs district; Lander County, principal silver ore at Cortez, Little Gem, Phoenix, and Gold Quartz mines; Lyon County, Bluestone and other mines in Yerington district; Nye County, Silverbow district; small quantity at Tonopah mine, Tonopah; White Pine County, Nevada Consolidated, Cumberland, and other mines in Ely district.

Chrysocolla. Elko County, important ore in Bullion district, Standing Elk principal mine; Esmeralda County, occurs in various prospects, Oriental Wash district; Humboldt County, sparingly at Red Butte and Munroe Hill, Chafey district; Lyon County, in Ludwig mine, Yerington district; Nye County, Bullfrog district, carries gold; in veins at Oak Spring.

Cinnabar. Esmeralda County, near Black Butte, Goldfield district, not mined; Eureka County, Lynn mining district; Humboldt County, near Fitting in American Canyon, Piute Range, in prospect on edge of Black Rock desert few miles south of Red Butte; in Eldorado Canyon; in Winnemucca Mountain, and in gold ores at National: Nye County, mined near Ione and Bonita, prospected on Bear Mountain; in old Barcelona silver mine at Belmont; Washoe County, very small quantity taken years ago near western margin of sinter at Steamboat Springs.

Clay (brick). Esmeralda County, dug at Goldfield; Lyon County, 1 mile west of Yerington; Washoe County. Reno.

Clay (fire). Ormsby County, deposit in Alumina mine Delaware district, not used.

Coal. Elko County, beds of shaly coal in Tertiary, Centennial Range, Bull Run Basin; Esmeralda County, extensive deposits of subbituminous coal in southern and western part of county; between Silver Peak and Candelaria, 4 beds, 6 to 8 feet; 4 miles south of Coaldale, 4 beds.

Cobalt. *See* Erythrite.

Copper. Ores of copper are of chief importance in following districts: Churchill County, Whitecloud (Coppereid); Clark County, Bunkerville (Copper King), Great Eastern, Logan (St. Thomas); Douglas County, Spruce Mountains, Wellington; Elko County, Contact, Dolly Varden, Elk Mountain; Humboldt County, Jackson Creek, Red Butte; Lander County, Kimberley (Hill Top); Lyon County, Yerington (Mason); Mineral County, Sodaville (Pilot Mountain); White Pine County, Ely (Robinson).

Copper minerals. *See* Azurite, Bornite, Chalcanthite, Chalcocite, Chalcopyrite, Chrysocolla, Covellite, Cuprite, Enargite, Malachite, and Tetrahedrite.

Copper (native). Esmeralda County, reported in surface panning in Goldfield district; Humboldt County, near Red Butte district; Lyon County, Nevada Douglas, Mason Valley, and Bluestone mines, Yerington district.

Corundum. Esmeralda County, reported from near Silver Peak.

Covellite. Humboldt County, occurs sparingly in Red Butte district; White Pine County, with copper ores of Ely (Robinson) district.

Cuprite. Elko County, important ore in Bullion district, Standing Elk principal mine; Humboldt County, occurs with covellite, chrysocolla, and iron oxides at Red Butte, was mined in Bolivia district; Lyon County, Mason Valley mine, Yerington district.

Electrum. Humboldt County, principal mineral at National; Nye County, mined at Gibraltar mine, Bullfrog district.

Enargite. Elko County, in Tuscarora and Good Hope districts; Esmeralda County, Gold Bar and Victor mines, Goldfield district.

Erythrite (cobalt ore). Churchill County, rich mines in northeast part of county; Humboldt County, has been mined at Lovelock mine, Cottonwood Canyon, Pahute Range.

Famatinite. Esmeralda County, with native gold in Goldfield mines.

Freibergite. Elko County, silver ore in Good Hope district; was mined at Buckeye, Ohio, and other mines.

Galena. Clark County, Potosi and other mines in Goodsprings district, argentiferous; Elko County, has been mined for gold and silver at Big Four, Columbia, and other mines in Aura (Columbia) district; in Dolly Varden, Ruby Valley, Spruce Mountains, Tecoma, and other districts; Esmeralda County, sparingly with rich gold ores at Goldfield, argentiferous; at Redemption mine near Hornsilver, in Buena Vista, Hornsilver, Lida, Lone Mountains, Palmetto, and other districts; Eureka County, important silver ore at Cortez, Mineral Hill, Safford, and Schroeder districts; Eureka district, at Ruby Hill, Tip top, Richmond, and other mines; Humboldt County, Pfluger mine, Humboldt Range, and in Adar, Chafey, Seven Troughs, and other districts; Lander County, in Campbell, Cortez, Galena, Kimberley, and Reese River districts; worked for gold at Tenabo; Lincoln County, in Comet, Geyser, Highland Valley, Hiko, Jackrabbit, Lone Mountain, and Pioche districts; Lyon County, Pine Nut and Yerington districts; Washoe County, at Wedekind and other mines 1 mile north of Sparks; formerly mined at Galena; White Pine County, Bunker Hill-Sullivan mine, Granite district, in Ward, Hunter, Hamilton, Ely, and Newark districts.

Gold (lode). Predominant in following districts: Churchill County, Bernice, Boyer, Eaglesville, Eastgate, Fairview, Jessup, White Plains; Clark County, Crescent, Eldorado Canyon, Gold Butte, Lyons, Searchlight, Vincent; Douglas County, Gardnerville, Red Canyon; Elko County, Aura, Carlin, Centennial, Cornucopia, Cornwall Basin, Gold Circle (Widas), Good Hope, Jarbidge, Tuscarora, Van Dusen; Esmeralda County, Buena Vista, Cuprite, Dyer, Goldfield, Gold Mountains, Hornsilver, Lida, Montezuma, Oriental Wash, Palmetto, Silver Peak, Southern Klondike, Windypah; Eureka County, Mill Canyon, Lynn; Humboldt County, Central, Disaster, Fitting, Gold Banks, Kennedy, National, Spring Creek, Rebel Creek, Seven Troughs, Vicksburg, Winnemucca; Lander County, Battle Mountain, Washington; Lincoln County, Chief, Eagle Valley, Ferguson, Freiberg; Lyon County, Ramsey, Silver City, Tallapoosa; Mineral County, Aurora, Bovard, Granite, Pine Grove, Rawhide, Santa Fe, Silver Star; Nye County, Bare Mountain, Bellehelen, Berlin, Big Dune, Blakes Camp, Bullfrog, Cactus Spring, Cloverdale, Eden, Gold Bar, Gold Crater, Golden, Goldyke, Hannapah, Jefferson Canyon, Johnnie, Kawich, Manhattan, Millett, Monte Cristo, Oak Spring, Round Mountain, Silverbow, Stonewall Mountain, Wellington; Storey County, Comstock; Washoe County, Cottonwood, Deep Hole, Peavine, Sheepshead, White Horse; White Pine County, Black Horse, Gold Canyon, Osceola, Steptoe. Besides the districts named in which gold is the predominant metal produced, there are others, as Tonopah district, Nye County, in which there is a large annual production of gold.

Gold (placer). Produced in 1910 in following districts: Elko County, small production near Tuscarora; Esmeralda County, small production from Lida district; Eureka County, five placers operated in Lynn district; Humboldt County, five placers in Spring Valley district; Lander County, new camp at Bannock, 16 miles southwest of Battle Mountain; Nye County, 37 placers in Manhattan and Round Mountain districts.

Goldfieldite. Esmeralda County, with gold, marcasite, and famatinite in Goldfield district.

Graphite. Humboldt County, occurs in Sierra Mountains; Ormsby County, mined 3 miles from Carson for making paint.

Gypsum. Best-known deposits are in Clark County, in Spring Mountains near Las Vegas, Arden; Esmeralda County, large bodies near Hawthorne; Humboldt County, near Lovelocks; Lyon County, Moundhouse, and an extensive bed at Ludwig mine, Yerington district. Two plaster mills at Moundhouse, one at Reno and one at Arden.

Hematite. Clark County, low-grade oolitic near Las Vegas, not mined; Eureka County, mined at Borth, shipped; Humboldt County, mined near Lovelocks, reported 30 miles south (?) of Golconda; Lyon County, high-grade hematite abundant in surface outcrops 12 miles northeast and 2 miles southwest of Dayton; Ormsby County, Bessemer mine.

Hübnerite. Esmeralda County, occurs near State line west from Lida; Humboldt County, occurs 15 miles south of Golconda in Gold Run district, in Sonoma Mountains in silver ores; Mineral County, occurs in Redlich; Nye County, occurs with gold ore at Tonopah, mined at Round Mountain and Ellsworth; White Pine County, mined at Hub, 12 miles southeast of Osceola, on Mount Wheeler, at Regan.

Infusorial earth. Storey County, mined at Chalk Hills ranch 9 miles northeast of Virginia City, for polishing powder; Washoe County, occurs in great quantity on banks of Little Truckee River between Pyramid and Winnemucca lakes, and in a railroad cut 4 miles west of Reno; also near Verdi; Esmeralda County, forms lenticular beds in the Seibert formation near Goldfield. Reported also in Fossil Hills and along northeast edge of Kawich Hills. Common in various other parts of State.

Jamesonite (antimonial lead ore). Esmeralda County, occurs 15 miles east of Thorne; Eureka County, in quartz at Hoosac mine, Eureka district, has been mined for silver; Humboldt County, abundant at Sheba and De Soto mines in Star Canyon, has been mined for silver at Sheba mine.

Kalinite. *See* Alum.

Kaolin. Humboldt County, deposit under development 24 miles southeast of Lovelocks; Ormsby County, large deposit 4 miles from Carson.

Lead minerals. Lead is the principal metal produced in following districts: Elko County, Ruby Valley, Spruce Mountains, and Tecoma districts; Eureka County, Cortez and Schroeder; Humboldt County, Cedar district; Lincoln County, Comet and Highland Valley; Mineral County, Lucky Boy; Washoe County, Leadville and Washoe (Galena); White Pine County, Hunter and White Pine; occurs less abundant in other districts. *See also* Anglesite, Cerusite, Galena, and Jamesonite.

Limestone (building). Humboldt County, abundant good building stone near Lovelocks. Some of the abundant limestones of the eastern half of the State might yield good building stone.

Limestone (lime). Ormsby County, formerly quarried several miles southeast of Carson City. Limestone suitable for lime is common in eastern half of State; scattered occurrences in western half of State.

Limonite. *See* Brown iron ore.

Magnetite. Clark County, with platinum in Copper King district; Eureka County, near Palisade; Humboldt County, in masses near Lovelocks, Pahute Range; Lyon County, with limonite and hematite near Dayton.

Malachite. Elko County, prominent ore of Bullion district, Standing Elk mine, carries silver and gold; Esmeralda County, Cuprite, Goldfield, and Montezuma districts; Eureka County, in oxidized ore at Ruby Hill, Eureka district; Humboldt County, small quantities in Red Butte district, has been mined in Bolivia; Lyon County, Mason Valley mine, Yerington copper district; Nye County, mined for gold at one mine in Bullfrog district, Silverbow district, carries gold and silver; Ormsby County, with copper ores 9 miles east of Carson City, carries gold and silver; White Pine County, Cumberland, Ely, Nevada Consolidated, Giroux, and other mines.

Manganese minerals. *See* Pyrolusite and Wad.

Marble. Elko County, La Neville Valley; Mineral County, near Luning; Nye County, occurs in Bullfrog district; White Pine County, abundant near Grandy.

Massicot. Esmeralda County, Redemption mine 1½ miles south of Hornsilver.

Mica. Lincoln County, 2 miles east of Gold Butte, has been mined and shipped.

Mimetite. Eureka County, in oxidized ore at Ruby Hill and in Eureka district.

Molybdenite. Reported near head of Death Valley. Otner localities are: Lyon County, in pegmatite in Yerington district; Mineral County, in quartz veins at Redlich; Nye County, prospected with powellite and scheelite at Oak Springs, 45 miles north of Johnnie Siding.

Monazite. Ormsby County, occurs in black sands at Carson City.

Nickel. Clark County, occurs with pyrrhotite and chalcopyrite in Copper King district, 16 miles south of Bunkerville; Churchill County, with silicates and sulphides 40 miles east of Lovelocks. *See also* Annabergite.

Obsidian. Occurs in regions of Tertiary volcanic rocks; small quantities cut for gems purposes.

Ocher. Humboldt County, replacement deposits in limestone near Golconda.

Opal. Lander County, prospected near Austin; Humboldt County, 20 miles south of Oregon and 40 miles east of California line; Nye County, reported in Ione district, and as milky opal with cinnabar on Bare Mountain.

Platinum. Clark County, prospects with copper and nickel in Copper King district, 16 miles south of Bunkerville.

Polybasite. Esmeralda County, in Florence mine near Goldfield; Lander County, in Cortez silver deposits; Nye County, Tonopah mine, Tonopah.

Proustite. Elko County, silver ore at Protection mine in Mountain City; Esmeralda County, possibly in ore of Florence mine near Goldfield; Humboldt County, Dreamland mine, Rosebud district; Lincoln County, Rich Hill mine; Nye County, Silverbow.

Psilomelane. Warren County, large deposit at Happy Creek.

Pyrargyrite. Elko County, important silver ore in Humboldt mine at Columbia, also mined at National; Nye County, Tonopah district.

Pyrite. Common and widely distributed in many mining districts. A few places where it has been mined for gold or silver are the following: Elko County, mined for gold at Dexter, Tuscarora, and Columbia mines; Esmeralda County, mined for gold at Goldfield; Eureka County, carries gold at Ruby Hill in quartzite and unoxidized ore, important silver ore at Mineral Hill; Humboldt County, mined for silver at Sheba mine, Humboldt Range, also at Seven Troughs district and Chafey, Piute Range; Lander County, principal silver ore at Cortez, worked for gold at Tenabo; Lyon County, principal mineral at Yerington mine; Nye County, at Crappmans, Oak Spring, and elsewhere, carries gold and silver; Ormsby County, Ozark mine, mined for sulphur and gold; White Pine County, small quantity in gold veins, Osceola district, important ore in Ely district, in Robinson, Cumberland, Ely, Nevada Consolidated, and Giroux mines.

Pyrolusite (manganese oxide). Humboldt County, small deposit near Golconda on Humboldt River; Warren County, large deposit at Happy Creek.

Pyromorphite. Elko County, surface mineral of Cornucopia mines at Tuscarora; Eureka County, mined for silver at Mineral Hill.

Pyrrhotite. Clark County, in peridotite dikes with platinum in Copper King district, probably nickeliferous.

Quartzite. Eureka County, Ruby Hill, has been used as siliceous flux.

Quicksilver. *See* Cinnabar.

Salt. Churchill County, brine pumped at Leete and Parran; Clark County, extensive bed at St. Thomas, used locally; Esmeralda County, found in various places, shipped for table and dairy purposes; Eureka County, deposit in north part Diamond Valley, has been mined extensively; Washoe County, brine pumped at Sheepshead.

Sand and gravel. Dug in Clark County, at Rox; Humboldt County, at Perth.

Sand (glass). Ormsby County, in quantity 4 miles from Carson.

Sandstone. Eureka County, quarried along Prospect Mountain south of Eureka; Humboldt County, has been quarried near Winnemucca; Ormsby County, formerly at State Prison, Carson City.

Scheelite. Humboldt County, small grains through limestone; mined 4 miles from Browns; prospected in Paradise Mountains in New Goldfield district; Nye County, first discovery prospect with hübnerite at Ellsworth; with powellite near Oak Springs; White Pine County, small flakes with hübnerite at Hub, near Osceola.

Shale. Eureka County, has been quarried at New York Canyon, Eureka, for furnace brick.

Silver. Predominant metal in following districts: Churchill County, Alpine, I X L, West Gate, Wonder; Elko County, Bullion (Railroad); Esmeralda County, Lone Mountain; Eureka County, Eureka, Mineral Hill, Safford; Humboldt County, Humboldt, Lovelocks, Rosebud, Star; Lander County, Bullion, Campbell, Cortez, Dean, Galena, Reese River (Austin), Skookum; Lincoln

County, Bristol, Geyser, Hiko, Jackrabbit, Lone Mountain, Patterson, Pioche; Mineral County, Columbus (Candelaria); Nye County, Belmont, Lodi Valley, Revielle, Tonopah, Trappmans, Tybo; Washoe County, Wedekind; White Pine County, Aurum (Silver Canyon), Newark, Ward. Of less importance in ores of many other districts. .

Smithsonite (carbonate of zinc). Clark County, principal mineral of Goodsprings district, Potosi, Rover, Monte Cristo, and other mines, mined and shipped; Eureka County, in oxidized ore at Ruby Hill and Eureka districts.

Soda. Esmeralda County, near Hawthorne.

Sphalerite (zinc blende). Elko County, important silver ore at Columbia, has been mined; Esmeralda County, sparingly in principal mines of Goldfield district; Eureka County, important silver ore at Mineral Hill; Humboldt County, Pfluger mine, Humboldt Range, and Chafey mine, Piute Range, Adelaide mine, Sonoma Range; Lander County, principal silver ore at Cortez, also worked for gold at Tenabo; Nye County, small quantity in Tonopah mine and Oak Spring; Washoe County, Wedekind district, north of Sparks; formerly mined at Galena.

Stephanite. Elko County, silver ore mined at Protection mine in Mountain City; Humboldt County, Seven Troughs district; Lander County, in Cortez silver deposits; Lincoln County, Rich Hill mine, Eldorado Canyon; Nye County, Tonopah mine, Silverbow.

Stetefeldite. Esmeralda County, original sulphide ore of veins in Southern Klondike district, silver bearing; reported in other silver-producing districts.

Stibiconite. Humboldt County, Rosebud, Juniper Mountain.

Stibnite. Churchill County, has been mined in Star district, 15 miles east of Lovelocks, at Boyer, and in Bernice district; Elko County, has been mined for silver at Columbia; Eureka County, mined for silver in Stafford district; Humboldt County, deposits have been worked in Trinity Range, in Star Canyon, in Bloody Canyon 2 miles south of Star Canyon, in Jackson Canyon, 1 mile north of Unionville, Juniper Mountain, Rosebud district, and in Seven Troughs district; Lander County, has been mined in Battle Mountain district, 6 and 10 miles south of railroad, and in Big Creek Canyon in Toyabe Range 12 miles south of Austin.

Stromeyerite. Lander County, in Cortez silver deposits.

Sulphur. Esmeralda County, large deposits near Luning and Cuprite, prospected with alum 10 miles north of Silver Peak; Humboldt County, extensively mined formerly at Rabbit Hole, 5 miles northeast of Rosebud; Lyon County, small quantity native sulphur in quartz at Mountain View mine, Yerington district; Washoe County, large deposit north of Pyramid Lake.

Tetrahedrite. Elko County, important silver ore at Columbia; Esmeralda County, with gold in Combination mine, Goldfield; Eureka County, Mineral Hill, argentiferous, and Safford district; Humboldt County, occurs in most of silver-gold deposits of Humboldt and Piute ranges; Lander County, mined at Pfluger mine, Humboldt Range, secondary ore at Cortez silver deposits.

Trona (carbonate of soda). Abundant in Churchill and Mineral counties.

Tungsten minerals. *See* Hübnerite, Scheelite, and Wolframite.

Turquoise. Found in following places: Clark County, at Searchlight; Esmeralda County, Royal Blue mine near Millers, 9 miles northeast of Blair Junction, and at Candelaria; 4 miles northeast of Coaldale; Lyon County, 1½ and also 7 miles northwest of Yerington; Mineral County, 3½ miles south of Redlich; 8 miles southwest and 12 miles northeast of Sodaville.

Ulexite (borate of lime). *See* Borax.

Vanadinite. Clark County, with wulfenite, 4 miles east of Crescent.

Variscite. Esmeralda County, 9 miles east of Blair Junction, 4 miles northeast of Coaldale; Mineral County, 8 miles south of Sodaville.

Volcanic ash. Ormsby County, unlimited quantity 5½ miles east of Carson City on Carson River, and in many other localities.

Wad. Eureka County, Phoenix mine and elsewhere in Eureka district; Humboldt County, small undeveloped deposit 2 miles east of Golconda; Nye County, common in some veins of Bullfrog district, mined for precious metals.

Wolframite. Humboldt County, with silver ore in Gold Run district, Sonoma Mountains, 15 miles south of Golconda.

Wulfenite. Clark County, with vanadinite 4 miles east of Crescent; Esmeralda County, Redemption mine, 1½ miles south of Hornsilver; Eureka County, through oxidized ore at Ruby Hill and Eureka district; very fine specimens have come from the Eureka district.

Zinc. *See* Calamine, Smithsonite, and Sphalerite.

NEW HAMPSHIRE.

Arsenopyrite (arsenical pyrite, mispickel). Belknap County, occurs at Alton; Carroll County, with cassiterite at Jackson; Grafton County, at Groton, Haverhill, Lebanon, Lyman, and elsewhere; Hillsborough County, at Francestown and Weare, not mined.

Beryl. Merrimack County, gem beryl found at Danbury, not mined; Sullivan County, good gem material in mica mine at Springfield, not mined.

Bornite. Carroll County, with chalcopyrite and cassiterite at Jackson; Coos County, with copper and zinc ores at Shelburne and at Milan, mined at latter place; Grafton County, with chalcopyrite in White Mountain mine at Littleton, was formerly mined.

Brown iron ore. *See* Limonite.

Cassiterite. Carroll County, at Jackson, mined in small way in 1843 and 1864.

Chalcocite (copper glance). Coos County, mined near Milan, with galena; carries gold and silver.

Chalcopyrite. Carroll County, has been mined with lead-silver ore near Ossipee; Coos County, near Gorham and Milan; Grafton County, at Warren and in mines at Bath, Monroe, Lyman, and Littleton (Gardners Mountain); Merrimack County, at Silverdale mine, near Pittsfield; Sullivan County, at Croydon and Unity.

Clay (brick). Brick yards were operating at the following places in 1911; Belknap County, the Weirs; Cheshire County, Keene; Coos County, Lancaster; Grafton County, Bath, Lebanon, and Plymouth; Merrimack County, Concord and Hookset; Rockingham County, Epping, Kingston, Exeter, North Epping, and Plaistow; Strafford County, Dover, Dover Point, East Barrington, Gonic, Farmington, and Rochester.

Clay (pottery). Cheshire County, one pottery is operating at Keene.

Essonite. Grafton County, found at Warren.

Flagstone. Slates and schists quarried for local use at localities in the Connecticut Valley.

Fluorspar. Cheshire County, mined near Westmoreland.

Galena. Carroll County, has been mined near Ossipee and Madison; Coos County, near Shelburne, Gorham, and Milan; Grafton County, at Warren and Woodstock, and with copper ore at mines of Gardner Mountain; Merrimack County, at Loudon and at the Silverdale mine, Pittsfield.

Garnet. Merrimack County, deposit worked at North Wilmot for abrasive material.

Gold. Coos County, minute quantities in alluvial sands, headwater of Indian Creek; Grafton County, free gold formerly mined in upper levels of Dodge mine near Lyman and at Bath; occurs in small quantity in quartzose conglomerate rock at Lisbon and Landaff, Lyman, and North Haverhill.

Granite. Quarried at the following places: Carroll County, Conway (3 quarries) and at Madison; Cheshire County, Fitzwilliam township (4 quarries), Marlboro, and Troy, formerly at Roxbury and Swanzey; Coos County, Kilkenney and Stark, formerly at Columbia; Grafton County, Canaan, Haverhill, and Lebanon; Hillsborough County, Brookline (2 quarries), Manchester (2 quarries), Milford (14 quarries), and Nashua, formerly at Pelham and Mason; Merrimack County, Allenstown, Concord (9 quarries), and Hookset; Rockingham County, Auburn, formerly at Salem; Strafford County, Rochester, formerly at Farmington; Sullivan County, Sunapee (3 quarries).

Graphite. Formerly mined in Cheshire County at Nelson, Merrimack County at Potter Place, and Sullivan County at Goshen.

Infusorial earth. In large quantities in north part of State: Belknap County, small deposit at Laconia; Carroll County, Bemis Lake, Stamp Act Island, Tanworth, and Wolfborough; Cheshire County, Fitzwilliam; Coos County, Lake Umbagog and Stark; Grafton County, small deposits at Livermore and Littleton were formerly used. None is now mined on a commercial scale.

Limestone (lime). Grafton County, was burned at Haverhill, Lisbon, and Littleton.

Limonite. Small deposits in various parts of the State, not mined.

Magnetite. Formerly mined at Carroll County, Bartlett; Cheshire County, Winchester; Grafton County, Franconia, Piermont.

Malachite. Grafton County, occurs at Franconia, Hanover, Littleton, and Orford, with copper ores.

Marls. Coos County, Lime Pond, Columbia; Hillsborough County, Hollis, not used.

Mica (chiefly muscovite). Belknap County, has been mined at New Hampton; Cheshire County, was formerly mined at Alstead, Gilsum, Keene, and Marlboro; Coos County, has been mined at West Milan; Grafton County, is mined at Alexandria and Groton, was formerly mined at Hoyt Hill, Tugg Hill, Grafton Center, and Orange; Merrimack County, was formerly mined at Wilmot; and Sullivan County, at Acworth and Springfield.

Ocher. Numerous small deposits of ocherous bog iron ore, not mined.

Peat. Numerous localities, especially in northern part of State. A bog in Rochester, Strafford County, was worked during the Civil War for manufacture of fuel.

Pyrite. Coos County, mined with copper ores of Milan, formerly mined with lead-silver ore near Shelburne; Grafton County, mined for manufacture of sulphuric acid at Lyman; Merrimack County, has been mined with galena at Silverdale mine, Pittsfield; Sullivan County, cupriferous pyrite has been mined at Croydon and Unity.

Pyrrhotite. Grafton County, formerly mined with copper ores of Bath, Monroe, Littleton, and Lyman; Sullivan County, known at Croydon and Unity, not mined.

Quartz. Hillsborough County, formerly quarried at Lyndeborough for glass making.

Silver. Coos County, has been produced as by-product from pyrite ores at Milan mine, West Milan.

Slate. Grafton County, formerly quarried at Hanover, Lebanon, and Littleton; also Sullivan County, Croydon Mountain, Cornish.

Sand and gravel. Dug at several places for road material.

Soapstone. Cheshire County, occurs but not now quarried at Richmond and Keene; Coos County, Lancaster; Grafton County, slaty character at Orford, large bed at Haverhill; Hillsborough County, Francestown and Weare; Merrimack County, Canterbury and Warner.

Sphalerite (zinc blende). Carroll County, formerly mined with silver-lead ores at Madison; Coos County, mined at Warren mine, and Milan mine (rare), Milan, formerly mined near Shelburne and near Gorham; Grafton County, formerly mined at Woodstock and Warren, and with copper ores of Gardner Mountain.

Tin. *See* Cassiterite.

Topaz. Carroll County, Baldface Mountain, near North Chatham, not mined.

Whetstone. Grafton County, mica schists or fine-grained micaceous sandstone quarried at Haverhill, Lisbon, Littleton, Piermont, and Pike.

Wolframite. Carroll County, small quantities in cassiterite veins at Jackson, not mined.

NEW JERSEY.

Agate. Hudson County, has been found at Hoboken; Somerset County, Boundbrook and Liberty Corner.

Amethyst. Hudson County, occurs in small quantity in Weehawken tunnel; Passaic County, at Little Falls; Somerset County, in geodes at Lyons Station; Sussex County, at Franklin Furnace.

Apatite. Morris County, large quantity mixed with magnetite at Ferromonte near Dover, also found at Hurdtown, Mount Pleasant, and Hibernia mines.

Azurite. *See* Copper minerals.

Braunite. Hunterdon County, occurs near Clinton, in small deposits.

Brown iron ore (limonite). Many old limonite mines were formerly worked: Cumberland County, Beatyestown, Shiloh; Hunterdon County, Califon and Bird mines; Morris County, German Valley, Denmark mine, Copper and Chester mines, Hacklebarney; Sussex County, Andover mine, Edsall mine near Hamburg, Pochuck mine near McAfee; Warren County, Marble Mountain, Fittz, and Shoemaker mines.

Cement material (Portland). Three large producing plants, the Alpha, the Vulcanite, and the Edison in Warren County. Extensive deposits of limestone of suitable quality in several counties.

Chalcocite. Hudson County, occurs in Schuyler mine; Hunterdon County, Neshanic mine; Middlesex County, mines near New Brunswick; Somerset County, has been mined at American Copper mine, Somerville; Warren County, has been mined at Pahaquarry mine.

Chalcopyrite (copper pyrites). Occurs in Hudson County, Arlington mine; Hunterdon County, Flemington mine; Middlesex County, mines near New Brunswick; Somerset County, Griggstown and Somerville mines.

Chrysocolla. *See* Copper minerals.

Clay (brick). Dug in Atlantic County, at Bakersville, Mays Landing, and Egg Harbor; Bergen County, Hackensack, Carlstadt, and Little Ferry; Burlington County, Crosswicks Creek at Crosswicks, and near Bordentown and Kinkora; Camden County, Collingswood and Delair; Cape May County, Belle Plain; Cumberland County, Bridgeton, Clayville, and Rosenhayn; Gloucester County, Woodbury; Hudson County, Homestead; Hunterdon County, Flemington; Mercer County, Trenton; Middlesex County, Woodbridge, South River, and elsewhere; Monmouth County, Cliffwood, Keyport, Lorillard, Matawan Creek, and West Asbury; Morris County, Logansville, Morristown, and Whippany; Ocean County, Herbertsville and Toms River; Passaic County, Little Falls, Mountainview, and Singac; Salem County, Penton station and Yorktown; Somerset County, east of Rocky Hill and at Somerville; Sussex County, small quantity dug at Newton; Union County, Berkeley Heights and Plainfield; Warren County, Brass Castle and Phillipsburg.

Clay (fire). Dug in Burlington County, at Bridgeboro and Florence; Camden County, Morris Station and near West Palmyra; Gloucester County, Bridgeport and Billingsport; Mercer County, sagger clay at Mercer Station and Dogtown; Middlesex County, Woodbridge, Milltown, South Amboy, and elsewhere, pipe clay dug at Burt Creek; Ocean County, sagger clay dug at Waretown, Davenport; Warren County, Port Murray.

Clay (pottery). Dug in Camden County, at Haddonfield; Essex County, Newark; Monmouth County, Matawan; Morris County, Logansport; Union County, in vicinity of Linden; Middlesex County, ball and slip clay dug at Woodbridge, Sayreville, and South Amboy.

Copper minerals. Azurite, chrysocolla, cuprite, and native copper occur wherever copper has been mined in the State but in very small quantity. *See also* Chalcocite, Chalcopyrite, and Malachite.

Cuprite. *See* Copper minerals.

Diasbase. *See* Road metal.

Flagstone. Formerly quarried in Mercer County, at Woodsville; Sussex County, Bearfort Mountain, Flagstone Hill, and Quarryville.

Fluorspar. Sussex County, occurs in minor quantity throughout the zinc ore at Franklin Furnace.

Franklinite. Sussex County, most abundant ore mineral at Franklin Furnace and Sterling Hill, mined chiefly for zinc oxide.

Garnet. Morris County, abundant at Nolands Point, Lake Hopatcong, also at Ironia; Passaic County, Hope mine, Ringwood; Warren County, Cummings iron mine.

Gneiss (crushed stone). Morris County, quarried at Montville, 2 miles northeast of Boonton and at Morristown; Passaic County, near Pompton, and at Haskell.

Granite (crushed stone). Morris County, quarried at Boonton near Dover, German Valley, Mount Arlington, and elsewhere; Passaic County, near Pompton, Haskell, and Charlotteburg; Sussex County, near Waterloo and Cranberry Lake.

Graphite. Hunterdon County, occurs at Califon and High Bridge; Morris County, occurs at Mendham and Morristown, has been mined at Bloomingdale; Passaic County, numerous places in Wanaque Valley; Somerset County, Pottersville and Peacock; Sussex County, Franklin and elsewhere.

Hematite (red iron ore). Sussex County, was formerly mined in Simpon and Cedar Hill mines near McAfee; Warren County, small quantity mined at Marble Mountain.

Infusorial earth (tripolite). Morris County, Drakeville; Sussex County, small quantities formerly used for manufacture of giant powder, near Andover. Not now mined.

Iron. *See* Brown iron ore, Hematite, and Magnetite.

Limestone (building). Hunterdon County, small quantities quarried at Clinton; Sussex County, near Deckertown, Franklin, and Newton, local use; Warren County, Blairstown, Carpenterville.

Limestone (crushed stone). Hunterdon County, quarried at Clinton, Califon, and Vernoy; Sussex County, Ogdensburg; Warren County, Finesville.

Limestone (flux). Hunterdon County, quarried at Annandale, Clinton, Califon, and elsewhere; Sussex County, at Hamburg, McAfee, Port Jervis, and elsewhere; Warren County, Bloomsburg, Carpenterville, Murry, and elsewhere.

Limonite. *See* Brown iron ore.

Magnesite (carbonate of magnesia). Hudson County, occurs near Hoboken, with serpentine.

Magnetite (magnetic iron oxide). Following is a list of mines formerly operated in Sussex County: Andover group, 4 miles south of Newton; Ford group, 3½ miles southeast of Sparta; Ogden group, at Edison; Sherman group, 1 mile southeast of Sparta; Sickles mine, 3 miles south of Sparta; Franklin Furnace, group extending southwest from the zinc mines at Franklin Furnace. Morris County, has been mined at Mount Hope, Richard, Hoff, Hurd, and Hibernia mines, at Rockaway Valley mines near Taylorville, mines near Splitrock Pond, Montville, and Riverdale; Passaic County, at Ringwood mines; Sussex County, the Stanhope and Ahles mines; Warren County, Oxford Furnace mine.

Malachite (green copper carbonate). Essex County, occurs in sandstone at Belleville and Bloomfield, has been mined at Belleville; Hudson County, occurs at East Belleville; Somerset County, has been mined at Somerville; Union County, occurs in Triassic sandstone at Chimney Rock, near Plainfield; Warren County, has been mined at Pahaquarry.

Marble. Sussex County, small quantity formerly quarried near Andover and Roseville; Warren County, formerly quarried near Upper Harmony, Marble Mountain, and Jenny Jump Mountain near Danville.

Marl. Small quantities of greensand marls dug from Raritan Bay across Monmouth, Ocean, Burlington, Camden, Gloucester, and Salem counties, to Delaware River; recently dug in quantity at Sewell, Gloucester County. Calcareous marls at Shiloh, Cumberland County, dug for local use.

Menaccanite. Morris County, occurs in Dell and Fichtor mines.

Molybdenite. Sussex County, occurs in Hude, Stanhope, and Ogden mines.

Ocher. Camden County, occurs at Camden; Middlesex County, Lincoln; Warren County, mined recently near Phillipsburg.

Peat. Beds of peat in many swamps; was made into briquets near Lincoln Park in 1904–5.

Pyrite. Morris County, occurs in Old Copperas, Hibernia, and Hurdtown mines; Sussex County, with magnetite near Vernon, Waterloo; Warren County, Jenny Jump Mountain, Marble Mountain, Washington, Swaze, and other mines.

Pyrrhotite (magnetic pyrites). Morris County, occurs in Hurdtown mine; Sussex County, Longcore's mine.

Road metal. Baltimore gneiss quarried at Holland. Mica gneiss quarried near Byberry, Ford, Montville, Morristown, and Pompton. Diabase or trap rock quarried at Brookville, Lambertville, Marshalls Corners, Milburn, Moore, Mount Rose, Paterson, Plainfield, Springfield, Upper Montclair, and formerly along Palisades. Gabbro quarried extensively at Wayne. *See also* Granite, Limestone, and Trap rock.

Sand (building). Dug in Bergen County, at Hackensack and Wortendyke; Burlington County, Bordentown, Burlington, Florence, Palmyra, and elsewhere; Camden County, Morris station, Grenloch and Wilton; Cumberland County, Millville; Essex County, South Orange; Gloucester County, Swedesboro; Middlesex County, Monmouth Junction, Metuchen, Sayreville, and Woodbridge; Morris County, Succasunna, Oreland, Ironia, and Montville; Passaic County, Hawthorne and Oak Ridge; Sussex County, Stanhope; Warren County, Phillipsburg; also in small quantity at many other points.

Sand (fire). Middlesex County, firo sand and underlying Woodbridge fire clay dug at number of points for manufacturing fire brick.

Sand (filter). Burlington County, dug extensively at Birmingham; Cape May County, large output from Cape May.

Sand (glass). Camden County, dug at Penbryn and Wilton; Cumberland County, Cedarville, Millville, and South Vineland; Gloucester County, Williamstown; Middlesex County, Jamesburg.

Sand (molding). Dug in Burlington County, at Bordentown, Brown Mills, Burlington, Lumberton, Palmyra, and elsewhere; Camden County, Blenhein, Grenloch, and Morris Station; Cape May County, Belle Plain; Cumberland County, Millville and Cedarville; Gloucester County, Downer, Radix, and elsewhere; Middlesex County, Perth Amboy, South Amboy, and elsewhere; Morris County, Flanders; Passaic County, Little Falls; Sussex County, Stanhope; Warren County, Phillipsburg and Great Meadows.

Sandstone. Quarries, many abandoned: Bergen County, Closter and Ridgefield; Essex County, Pleasantdale and West Orange; Hunterdon County, Stockton and Raven Rock; Mercer County, Wilburta, Princeton, and elsewhere; Passaic

County, Passaic and Paterson; Somerset County, one-half mile northeast of Watchung and Martinsville.

Sandstone (brownstone). Quarries, many closed: Essex County, Pleasantdale; Hudson County, North Arlington; Passaic County, below Great Falls on east side of Passaic River, Paterson, and near Passaic; Somerset County, near Kingston.

Sandstone (conglomerate, puddling stone). Morris County, quarried at Green Pond; Passaic County, Bearfort and Kanouse mountains, attractive building stone.

Serpentine. Hudson County, projects out into Hudson at Stevens Point, and formerly quarried for local use; Morris County, scattered through limestone at Montville; Warren County, quarried at Phillipsburg, for decorative use.

Slate (roofing). Sussex County, quarried at Newton and Lafayette; Warren County, formerly quarried at Delaware Water Gap, and elsewhere.

Talc and soapstone. Sussex County, occur at Sparta, Lockwood, Andover, Franklin, and Newton; Warren County, quarried with serpentine near Phillipsburg.

Tephroite. Sussex County, occurs locally abundant at Franklin Furnace and Sterling Hill.

Trap rock. Quarried in Bergen County, at Cliffside Park and Bergen Hill; Essex County, Caldwell, Upper Montclair, Milburn, and elsewhere; Hudson County, Granton, New Durham, and elsewhere; Hunterdon County, Lambertville and vicinity; Mercer County, Hopewell, near Princeton and elsewhere; Middlesex County, Dunellen; Morris County, Millington; Passaic County, Paterson, Little Falls, and Great Notch; Somerset County, Bernardsville, Boundbrook, Somerville, and elsewhere; Union County, Summit, New Providence, Springfield.

Tripolite. *See* Infusorial earth.

Willemite (silicate of zinc). Sussex County, one of the abundant minerals at Franklin Furnace and Sterling Hill.

Zinc. *See* Franklinite, Willemite, and Zincite.

Zincite (red oxide of zinc). Sussex County, Franklin Furnace and Sterling Hill.

Zircon. Sussex County, abundant in magnetite at Williams mine.

NEW MEXICO.

Alum (alum rock). Grant County, large supply of aluminum sulphate 25 miles north of Silver City on both sides of Gila River; Union County, Ute Creek, not mined.

Alunogen. Grant County, both sides of Gila River, secs. 19, 20, 29, 30, T. 13 S., R. 13 W.

Anglesite. Luna County, Cooks Peak and Victorio districts, mined at Desdemona, Graphic, and Summit mines; Socorro County, mined in Magdalena district.

Anthracite. Santa Fe County, mined at Madrid, south of Cerrillos.

Antimony minerals. *See* Cervantite and Stibnite.

Argentite (silver glance, silver sulphide). Has been mined in the following districts: Dona Ana County, Organ (rare); Grant County, Black Hawk, Chloride Flat, Georgetown, Granite Gap, Kimball, Lone Mountain, Steeplerock, and Pyramid districts; Sandoval County, Cochiti; Socorro County, Cooney (Mogollon) and Socorro; Sierra County, Kingston, Hermosa, Tierra Blanca, Lake Valley, Black Range, and Apache districts.

Azurite (blue carbonate of copper). Mined with other copper ores in the following districts: Grant County, Burro Mountain and Sylvanite; Luna County, Fremont (a little); Rio Arriba County, Bromide, not important; Sandoval County, Nacimiento (red beds); San Miguel County, Tecolote; Sierra County, Chloride (Phillipsburg) and Caballos; Socorro County, Magdalena; Valencia County, Copperton (Zuni Mountains), red beds.

Barite. Valencia County, Zuni Mountains; 10-foot vein in Smelter Gulch prospected for silver.

Bismuth (native). Luna County, Fremont, with silver ores, rare; Socorro County, mined in 1911 and 1912 about 35 miles southwest of Tularosa.

Bismutite. Socorro County, mined 25 miles southwest of Tularosa.

Bornite. Mined in the following districts: Grant County, Kimball, small quantity, and Lordsburg, minor ore; Sandoval County, Nacimiento (red beds); San Miguel County, Rociada and Tecolote; Sierra County, Caballos, Chloride (silver bearing), Hermosa (silver bearing), Kingston (silver bearing); Socorro County, Cooney (Mogollon), important ore; Taos County, Twining. Occurs also in Santa Fe County with other copper ores; Lincoln County, Nogal Mountains; Rio Arriba County, Abiquiu district; Sierra County, Caballos Mountains.

Brochantite. Dona Ana County, Organ district; not mined.

Bromyrite. Sierra County, with gold and silver ores in Tierra Blanca district; was formerly mined.

Brown iron ore (limonite, brown hematite). Common in all oxidized ores. Grant County, small quantity mined with magnetite near Fierro, Union mines, formerly mined in Glorieta district; Valencia County, prospected at head of Smelter Gulch, Zuni Mountains.

Cement rock. Colfax County, Springer, natural cement formerly manufactured; Socorro County, limestone and shale suitable for Portland cement, near Carthage.

Cerargyrite (horn silver, silver chloride). Has been mined with oxidized ores in the following districts: Dona Ana County, Organ, rare; Grant County, Burro Mountains, Chloride Flat, Kimball, Hachita, Apache No. 2, Black Hawk, Georgetown, Lone Mountain, and Pyramid; Luna County, Fremont; Santa Fe County, San Ysidro Mountain; Sierra County, Lake Valley, formerly an important ore, Kingston, in placers, Hermosa, Hillsboro, Chloride (Phillipsburg), Black Range and Apache, and Tierra Blanca, rare; Socorro County, Cooney (Mogollon) and Socorro.

Cerusite (lead carbonate). Mined in the following districts: Dona Ana County, Organ; Grant County, Granite Gap, Hanover, with zinc ores, Hachita, and Lordsburg; Luna County, Cooks Peak and Fremont; Sierra County, Hillsboro, Lake Valley, very rich in silver, and Chloride (Phillipsburg); Socorro County, Magdalena.

Cervantite. Grant County, Central district; not mined.

Chalcocite (copper glance). Mined in the following districts: Grant County, Burro Mountain, with cupriferous pyrite, Hachita, Kimball, small quantity, Santa Rita; Otero County, Tularosa; Sandoval County, Nacimiento, principal ore of red beds; San Miguel County, Rociada and Tecolote; Sierra County, Caballos; Socorro County, Cooney (Mogollon), important ore; Taos County, Picuris. Known, but not mined: Rio Arriba County, Hermosa prospects; Santa Fe County, Lunto Mountains, in small quantities; Socorro County, small quantities at Sierra Oscura; Valencia County, in "Red Beds" in Copper Hill district and Zuni Mountains.

Chalcophanite. Socorro County, Magdalena; mined with smithsonite.

Chalcopyrite (copper pyrites). Has been mined in the following districts: Colfax County, Cimarroncito and Elizabethtown, small quantity; Dona Ana County, Organ, in copper deposits only; Grant County, Burro Mountains, Central, with galena, Fierro, with iron ore, Hachita, rare, Kimball, small quantity, Lordsburg, Pinos Altos, Santa Rita, Steeple Rock, and Sylvanite; Lincoln County, Nogal; Luna County, Fremont; Otero County, Jarilla, Tularosa, very little; Rio Arriba County, Bromide, Hopewell, minor ore; San Miguel County, Cooper (Pecos), Rociada, Tecolote; Santa Fe County, Cerrillos, a little, argentiferous and auriferous, Lunto and Santa Fe Mountains, San Pedro, principal ore; Sierra County, Caballos, Chloride (Apache); Socorro County, not plentiful, Cooney (Mogollon), Mogollon Mountains, with chalcocite, bornite, and native silver, argentiferous; Taos County, Red River, not abundant, Twining.

Chrysocolla. Mined with other copper ores in the following districts: Dona Ana County, Organ; Grant County, Apache No. 2, not prominent, Burro Mountains, and Lordsburg, not common; Otero County, Jarilla; Sandoval County, Nacimiento, red beds; Santa Fe County, Santa Fe Mountains; Socorro County, Oscura Mountains, in large quantity; Taos County, Picuris.

Clay (brick). Dug in Bernalillo County, at Albuquerque; Colfax County, Raton; Dona Ana County, Bickland; Grant County, Silver City; San Juan County, Farmington, Aztec, and Kirtland; San Miguel County, Las Vegas; Santa Fe County, Santa Fe.

Clay (fire). Mined in McKinley County, Clarkville and Gallup; Socorro County, at San Antonio.

Coal (bituminous and subbituminous). Bernalillo County, undeveloped bed along Rio Puerca near San Ygnacio; Colfax County, mined at Blasburg, Brilliant, Dawson, Koehler, Van Houten; Lincoln County, mined at Capitan and White Oaks; McKinley County, mined at Clarksville and Gallup, Hosta Butte, not mined, Raton Springs, local use, and near Zuni, local use, San Mateo; Rio Arriba County, Gallina, not mined, Monero mined, Stinking Lake, not mined; Sandoval County, Chico Arroya, 15 miles northwest of Cabezon, not mined, Hagan, local use, 15 miles east of Bernalillo, Sierra Nacimiento, local use; San Juan County, Fruitland, local use, La Plata, Pendleton, Putnam, local use; San Miguel County, Rio Pecos, not mined; Santa Fe County, Omara, 18 miles southeast of Cerrillos; Socorro County, Carthage, mined; small quantity of coking coal about 25 miles northwest of Magdalena. *See* Anthracite.

Coke (natural). Santa Fe County, found with anthracite at Cerrillos Hills.

Copper (native). Socorro County, rare; Grant County, Pinos Altos, rare, and Santa Rita district, east of Silver City, important.

Copper minerals. Copper is the predominant metal produced in the following districts: Bernalillo County, Tyeras Canyon, 18 miles northeast of Albuquerque; Dona Ana County, Hembrillo; Grant County, Apache No. 2, Burro Mountains, Central, Pinos Altos, Santa Rita; Lincoln County, Estey; Otero County, Highrolls and Tularosa; Rio Arriba County, Abiquin, Bromide, Gallina; Sandoval County, Cuba, Placitas, Cooper, Mineral Hill, Tecolote; Santa Fe County, San Pedro; Sierra County, Caballos Mountains; Socorro County, San Andreas, San Lorenzo, Hansonburg; Taos County, Picuris, Twining; Valencia County, Copperton, Manzano.

Cuprite (ruby copper). Grant County, mined in Santa Rita district, east of Silver City, Hanover, formerly, and Burro Mountain district; Sierra County, Caballos; Socorro County, in limestone with zinc and lead ores at Magdalena and Mill Canyon; Taos County, Picuris. *See also* Azurite, Bornite, Chalcocite, Chalcopyrite, Chrysocolla, Cuprite, Malachite, Tetrahedrite, and Tenorite.

Descloizite. Grant County, Commercial mine, Georgetown.

Embolite. Sierra County, mined to small extent in Grande, Bella, and Apache mines, Lake Valley.

Endlichite. Sierra County, Lake Valley district and Hillsboro.

Epsomite. Torrance County, obtained at Estancia Lakes.

Fluorspar. Luna County, mined near Deming; Grant County, formerly mined for flux in Burro Mountain district.

Galena (generally argentiferous). Mined in the following districts: Bernalillo County, Soda Springs; Colfax County, Moreno, small amount; Dona Ana

County, Organ; Grant County, Burro Mountains, a little with gold ores, Central, principal ore, Granite Gap, with cerusite, Hachita, Hanover, very little with zinc ores, Kimball, small amount, Lordsburg, minor ore, Pinos Altos, with copper and gold ore, Steeple Rock, small amount, formerly mined; Lincoln County, Nogal, not plentiful; Luna County, Cooks Peak, Victorio, principal ore, Fremont, Tres Hermanas, with zinc ore; Rio Arriba County, Hopewell, sparingly; San Miguel County, Rociada, Cooper, rare; Sandoval County, Cochiti, rare; Santa Fe County, Cerrillos, prominent ore; Sierra County, Caballos, unimportant, Hermosa, principal ore, Kingston, principal ore, Lake Valley, very rich in silver, Tierra Blanca; Socorro County, Canyoncito, Magdalena; Taos County, Red River; Valencia County, Copperton, with copper ores.

Garnet (pyrope). San Juan and McKinley counties, found in Navajo Reservation, of value as gem but not mined.

Glauberite. Torrance County, with epsomite and salt at Estancia Lakes; not mined.

Gold (lode). Mined in the following districts, chiefly in oxidized zone: Colfax County, Elizabethtown, Moreno, Cimmaroncito, and Ute Creek; Dona Ana County, Black Mountain, Texas Creek; Grant County, Burro Mountains, Gold Hill, Kimball, Pinos Altos, Sylvanite, Steeplerock; Lincoln County, Jicarilla, Nogal, White Oaks; Sandoval County, Cochiti; Rio Arriba County, Bromide, Hopewell; Santa Fe County, Old Placers, San Pedro; Sierra County, Fremont, Chloride, Hillsboro; Socorro County, Cooney, Mogollon, Mill Canyon, Silver Mountain, Rosedale; Taos County, Anchor, Red River.

Gold (placer). Colfax County, Elizabethtown, Ponil, and Ute Creek; Grant County, Pinos Altos; Lincoln County, Jicarilla, Gallinas, and White Oaks; Otero County, formerly mined at Jarilla, dry placers, and elsewhere; Rio Arriba County, Hopewell; Santa Fe County, Old Placers, New Placers; Sierra County, Hillsboro, Pittsburg; Taos County, Red River.

Graphite. Colfax County, mined to small extent 8 miles southwest of Raton; Valencia County, occurs in Sandia Mountains, not mined.

Gypsum. Occurs in Bernalillo, Chaves, Dona Ana, Eddy, Guadalupe, McKinley, Otero, Quay, Rio Arriba, Roosevelt, Sandoval, San Juan, San Miguel, Santa Fe, Sierra, Socorro, Torrance, and Valencia counties. Used locally, but on a commercial scale only, in Chaves County at Acme, Lincoln County at Ancho, Otero County at Alamogordo, gypsum sands, and Rio Arriba County at El Rito.

Halite. *See* Salt.

Halotrichite. Grant County, both sides Gila River, secs. 19, 20, 29, 30, T. 13 S., R. 13 W.

Hematite. Common in oxidized ores throughout the State; Grant County, mined at Fierro; Santa Fe County, formerly mined in Glorieta district. *See also* Specularite.

Hübnerite. Lincoln County, in quartz with gold ores in White Oaks district.

Hydrozincite. Luna County, Tres Hermanas district, with willemite and smithsonite; Socorro County, in limestone at Magdalena, with smithsonite.

Iodyrite. Sierra County, with vanadinite, at Lake Valley.

Iron minerals. *See* Brown iron ore, Hematite, Magnetite, Pyrrhotite, and Specularite.

Lead minerals. Lead is the predominant metal produced in the following districts: Dona Ana County, Modoc and Organ; Grant County, Carpenter, Granite Gap, Hachita, and Red Hill; Luna County, Cooks Peak, Fremont, and Victorio; Santa Fe County, Cerrillos; Socorro County, Canyoncito. *See also* Anglesite, Cerusite, Galena, and Plumbojarosite.

Limestone (building and crushed stone). Present in many parts of the State: Mora County, quarried at Watrous; Otero County, abundant, not used.

Limestone (lime). San Miguel County, quarried at Las Vegas.

Limonite. *See* Brown iron ore.

Magnetite (magnetic iron ore). Colfax County, common in contact metamorphic deposits at Cimarron and Elizabethtown; Grant County, mined as iron ore at Fierro; Santa Fe County, at Old Placers, in gold quartz veins; Socorro County, mined as iron ore at Jones Camp.

Malachite. Mined with oxidized ores of the following districts: Grant County, Apache No. 2, Burro Mountains, Lordsburg, Pinos Altos, Santa Rita, Sylvanite; Luna County, Fremont; Otero County, Jarilla; Sandoval County, Nacimiento, red beds; San Miguel County, Tecolote; Sierra County, Caballos, Phillipsburg; Socorro County, Magdalena; Taos County, Picuris; Valencia County, Copperton, Zuni Mountains, red beds.

Manganese minerals. *See* Chalcophanite, Manganite, Psilomelane, Pyrolusite, and Wad.

Manganite. Sierra County, mined at Lake Valley, with silver ore.

Marble. Lincoln County, occurs in White Oaks district, white and black, not quarried; Otero County, quarried at Alamogordo.

Meerschaum. Grant County, small quantities shipped from prospects 12 miles northwest and 24 miles north of Silver City; Luna County, deposits at Gila River Canyon and Bear Creek, not mined.

Mica. Mined or prospected in following places: Rio Arriba County, Petaca; San Miguel County, Glorieta Mountains; Santa Fe County, Nambe, Santa Fe Mountains; Taos County, near Taos.

Molybdenite. Dona Ana County, occurs with other ores at Organ; Grant County, rare at Modoc mine, Fierro district, and with copper ores at Santa Rita; Rio Arriba County, Bromide, with copper ores; San Miguel County, Rociada, with copper ores.

Monazite. Sierra County, in black sands at Shandon, not mined.

Natural gas. Eddy County, two wells near Dayton; not used, 1909.

Onyx marble. Grant County, reported near Silver City; Lincoln County, reported near White Oaks; Otero County, deposits worked near Alamogordo.

Opal. Grant County, near Fort Bayard, has been prospected.

Petroleum. Chaves County, occurs near Artesia; Colfax County, has been found south of Raton; Eddy County, field at Dayton produces for local use; McKinley County, has been found in several wells in Seven Lakes field.

Plumbojarosite. Luna County, Cooks Peak, with lead ores.

Proustite (light ruby silver). Sierra County, with other silver ores in Kingston district.

Psilomelane. Sierra County, Lake Valley district, was mined for silver at Apache, Bella, and Grande mines.

Pyrargyrite. Grant County, Bullards Peak district, and Gold Hill near Silver City, formerly mined with sphalerite, argentite, and native silver; Sierra County, was formerly mined in Kingston and other districts; Socorro County, rare in Cooney (Mogollon) district.

Pyrite. Generally auriferous; mined in following districts; Colfax County, Elizabethtown (Moreno), Cimarron; Grant County, Burro Mountains, Fierro, with iron ore, Hachita, with silver ores, Hanover, with very little zinc ore, Kimball, Lordsburg, with chalcopyrite, Pinos Altos, Santa Rita, Steeplerock, Sylvanite; Lincoln County, Nogal, abundant, White Oaks, Jacarilla; Luna County, Cooks Peak with lead ores, Tres Hermanas, small quantity with zinc ores, Victorio, with galena; Otero County, Jarilla, Tularosa, very little, cupriferous; Rio Arriba County, Bromide, with copper ores, Hopewell; Sandoval County, Cochiti, plentiful; San Miguel County, Tecolote, small quantity with copper ores, Rociada; Santa Fe County, Cooper, with copper ore, San Pedro; Sierra

County, Hermosa, silver-bearing; Socorro County, Cooney, with copper and silver ores, Magdalena, with zinc ores; Taos County, Ancho, Red River, Twining, cupriferous; Valencia County, Copperton, cupriferous.

Pyrolusite. Grant County, with hematite and limonite coating quartz at Wood mine, Sylvanite district; Luna County, formerly mined in Tres Hermanas district; Sierra County, with silver ores in Lake Valley district.

Pyrrhotite. Colfax County, Elizabethtown (Moreno), locally with pyrite; Grant County, Fierro and Hanover district, with magnetite; Santa Fe County, San Pedro, small quantity with chalcopyrite.

Salt. Socorro County, 80 miles south of Gallup in western part of county; Torrance County, brine evaporated at Estancia, for local use.

Sand (building). Common throughout the State. Is dug at Raton, Colfax County, and near other towns and cities.

Sandstone. Colfax County, quarried at Cimarron and near Raton, building, curbing, etc.

Scheelite. Grant County, small quantity mined in Anderson-Apache copper mine at Hachita, and Daisy mine; San Miguel County, small deposit near Hermit Peak, not mined; Socorro County, has been mined with bismuth and copper ores on east side of San Andreas range, 37 miles west of Tularosa.

Silver (native). In oxidized ores of the following districts: Grant County, Granite Gap; Luna County, Victorio; Sierra County, Hermosa, Hillsboro, Lake Valley, rare, Phillipsburg, Tierra Blanca, Black Range, and Apache; Socorro County, Cooney (Mogollon), here an original mineral; Valencia County, Copperton; also at Black Hawk, Chloride Flat, Georgetown, Lone Mountain, Pyramid, not common, Grant County; and Kingston, Sierra County.

Silver ores. Silver is the predominant metal produced in the following districts: Grant County, Black Hawk, Chloride Flat, Georgetown, Kimball, Lone Mountain, Pyramid, Telegraph, Virginia; Lincoln County, Cedar Creek; Luna County, Florida Mountains; Sierra County, Chloride, Hermosa, Kingston, Lake Valley, Tierra Blanca; Socorro County, Socorro. *See also* Anglesite, Argentite, Cerargyrite, Embolite, Proustite, Pyrargyrite, and Xanthoconite.

Smithsonite. Grant County, Hanover; Luna County, Cooks Peak and Tres Hermanas; Santa Fe County, Cerrillos; Socorro County, Kelly, Magdalena, stones from Kelly cut as a gem.

Specularite. Mined with other ores in the following districts: Colfax County, Cimarroncito and Elizabethtown (Moreno), in contact metamorphic deposits; Dona Ana County, Organ, in contact metamorphic deposits; Grant County, Fierro, with magnetite, Burro Mountains, Central, Kimball, with silver, Pinos Altos, with copper and gold ores, Santa Rita, with copper ore, sparingly, Santa Rosa, with copper ores, not abundant, Steeplerock, with auriferous pyrite, no longer mined; Luna County, Cooks Peak, Tres Hermanas; Otero County, Jarilla, in contact metamorphic deposits; Rio Arriba County, Bromide, rare, Hopewell, sparingly with gold ores; Sandoval County, Cochiti, plentiful; Santa Fe County, Cerrillos, Old Placers; Sierra County, Lake Valley, in gold quartz veins, rare; Socorro County, Cooney, with copper ores, occasional, Magdalena; Taos County, Red River.

Stibnite (sulphide of antimony). Grant County, small quantity mined with silver ores at American mine, Hachita district; Santa Fe County, Cerrillos district, not mined.

Sulphur (native). Sandoval County, James, mined on a small scale.

Tedradymite. Grant County, Golden Eagle and Hand Car mines, Sylvanite district, mined for gold.

Tetrahedrite (gray copper, fahlerz). Dona Ana County, Organ; Rio Arriba County, with calcite in schist at Bromide mine, carries silver; Socorro County, in silver veins at Cooney (Mogollon), near Pueblo Springs, in quartz veins with chalcopyrite, highly argentiferous; Sierra County, has been mined at Chloride, Hermosa, and Kingston.

Tenorite. Grant County, occurs in Santa Rita, not mined.

Tungsten ores. *See* Hübnerite, Scheelite, and Wolframite.

Turquoise. Grant County, has been mined in Little Burro Mountains and Little Hachita Mountains; Otero County, Jarilla Mountains, between Jarilla and Las Cruces; Santa Fe County, Los Cerrillos.

Vanadinite. Grant County, with silver ores at Mimbres and McGregor mines, also found on Red Horse and White Horn claims, Georgetown district, mined at Lucky Bill mine, Bayard station; Sierra County, has been mined in Caballos Mountains, and with lead ores in Hillsboro district, occurs also in Bella, Apache, and Grande mines, Lake Valley district; Socorro County, mined at Kelly mine and found on other claims, Magdalena district.

Vanadium minerals. *See* Descloizite, Endlichite, and Vanadinite.

Wad. Sierra County, Lake Valley and other districts, was formerly mined.

Willemite. Luna County, Tres Hermanas district.

Wolframite. Grant County, Hachita, with argentiferous galena; Lincoln County, Homestake claims, White Oaks, with gold and silver; Luna County, small quantity mined in Victorio district, near Gage.

Wulfenite. Dona Ana County, mined with silver ores in Organ district; Grant County, Lordsburg; Sierra County, mined at Hillsboro, and reported from Caballos district.

Xanthoconite. Santa Fe County, Cerrillos district, was formerly mined.

Zinc minerals. *See* Hydrozincite, Smithsonite, and Willemite.

NEW YORK.

Abrasive. *See* Corundum, Garnet, and Millstone.

Allanite. Essex County, abundant in Smith mine, Mineville; Westchester County, occurs sparingly at Bedford feldspar quarries.

Almandite. *See* Garnet.

Apatite (phosphate of lime). Essex County, abundant in Old Red magnetite ores at Mineville, and obtained as by-product in their concentration, botryoidal and fibrous variety (Eupyrchroite) near Crown Point; Jefferson County, Vrooman Lake; St. Lawrence County, with calcite at Hammond, also near Gouverneur; Saratoga County, Greenfield.

Arsenopyrite (mispickel). Orange County, occurs near Edenville; Putnam County, occurs near Boyds Corner, has been mined near Pine Pond.

Asbestos. Dutchess County, found near Pawling; Orange County, near Greenwood Furnace; Putnam County, Phillipstown and Patterson; Richmond County, near Tompkinsville, in Serpentine Hill, Staten Island; Rockland County, Stony Point; Warren County, Thurman.

Barite (heavy spar). Columbia County, occurs at Ancram; Herkimer County, near Little Falls and Fairfield; Jefferson County, has been mined at Pillar Point; Onondaga County, near Syracuse; St. Lawrence County, Hammond, De Kalb, and Richville; Schoharie County, with strontianite in limestone near Schoharie, also at Carlisle.

Bluestone. *See* Sandstone.

Brown iron ore (limonite, brown hematite). Dutchess County, Amenia mine, the only producer in 1910. Was formerly produced in Columbia County, at Ancram, Boston Corner, Copake, Hillsdale, and Millerton; Dutchess County, at the Dover, Sylvan Lake, and other mines; Orange County, Townsend mine, Cornwall; Richmond County, Castleton, Four Corners, Newdorp, and Todt Hill, Staten Island.

Cement (natural). Natural cement mills are largely being supplanted by those producing Portland cement. Former important producers: Erie County, Akron; Onondaga County, Syracuse, Fayetteville, Manlius, and Jamesville; Schoharie County, Howe Cave; Ulster County, Rosendale and Lawrenceville.

Cement (Portland). Limestone and clays used: Columbia County, at Greenport and Hudson; Greene County, Cementon and Alsen; Schoharie County, Howe Cave; Tompkins County, Cayuga; Warren County, Glens Falls. Marls and clay used: Livingston County, near Caledonia; Onondaga County, Jamesville; Steuben County, Wayland.

Cerusite (lead carbonate). Lewis County, occurs at Martinsburg; St. Lawrence County, sparingly in Rossie lead mines; Westchester County, near Ossining.

Chalcopyrite (copper pyrites). Columbia County, occurs in Ancram lead mine; Orange County, near Edenville; St. Lawrence County, was mined in connection with lead near Rossie and Canton; Sullivan County, abundant with galena near Wurtsboro; Ulster County, Ellenville and Red Bridge lead mines.

Chromite. Orange County, occurs in Clove mine; Putnam County, in serpentine near Peekskill; Richmond County, disseminated in serpentine of Staten Island; Westchester County, disseminated in serpentine at Rye and New Rochelle.

Chrysoberyl. Saratoga County, formerly found abundantly in Greenfield; of gem quality.

Clay (brick). Widely distributed and utilized in nearly every county of the State. Extensively dug in counties bordering the Hudson River. Used for tile and terra-cotta ware by firms in Albany, Allegany, Erie, Kings, Monroe, New York, Oneida, Queens, Steuben, and Rensselaer counties.

Clay (fire). Richmond County, dug and shipped on Staten Island; Suffolk County, from Long Island.

Clay (kaolin). Dutchess County, dug at Shenandoah.

Clay (pottery). Dug intermittently in Chemung County, at Elmira; Dutchess County, Amenia; Monroe County, Chili; Oneida County, Utica; Onondaga County, Syracuse, Warner, and Amboy Station; Richmond County, Staten Island; Suffolk County, Long Island.

Clay (slip). Albany County, mined and shipped near Albany.

Corundum (emery). Westchester County, mined with spinel near Peekskill, and used as abrasive.

Corundum. Orange County, blue and white varieties occur in limestone near Amity.

Cyrtolite. Westchester County, found at Bedford feldspar quarries, utilized.

Diabase. *See* Trap.

Feldspar. Essex County, crushed pegmatite quarried for use in the manufacture of roofing material, and as poultry grit, at Crown Point and Ticonderoga; Fulton County, orthoclase and microcline for use in pottery mined near Northville; Saratoga County, has been mined at Batchellerville and Corinth; and in Westchester County, at Bedford and North Castle.

Flagstone. *See* Limestone (building) and Sandstone.

Fluorspar. Cayuga County, occurs sparingly at Auburn; Clinton County, abundant in Palmer Hill mine and occurs at Finch ore bed; Essex County, Burton Hill mines, Mineville; Jefferson County, Muscalonge Lake, Alexandria; Lewis County, Lowville; Monroe County, Rochester; Niagara County, Lockport; Onondaga County, Fayetteville and Manlius; Orange County, Amity and Edenville; Putnam County, Tilly Foster iron mine, Brewster; St. Lawrence County, De Kalb, Fine, Gouverneur, Hammond, and Macomb; Warren County, Johnsburg.

Galena. Columbia County, has been mined at Ancram; Lewis County, occurs at Martinsburg; Orange County, has been mined at Phoenix lead-zinc mine near Otisville; St. Lawrence County, has been mined at Rossie and vicinity, and occurs in limestone at Balmat mine between Edwards and Gouverneur, at Donovan mine at Macomb; Sullivan County, has been mined at Wurtsboro; Ulster County, has been mined at Ellenville and Red Bridge; Washington County, occurs at White Creek; Westchester County, has been mined near Ossining.

Garnet (almandite). Essex County, mined at Mount Bigelow, near Keeseville; St. Lawrence County, is an abundant constituent of many Adirondack gneisses, has been mined near Gouverneur; Warren County, mined at Johnsburg, Riparius, and North River, used as abrasive material.

Granite. Clinton County, quarried at West Chazy; Essex County, quarried intermittently at Ausable Forks; Fulton County, Gloversville; Jefferson County, Grindstone Island, northwest of Clayton, Picton Island, and Wellesley Island; Orange County, north end of Mount Adam, Warwick; Putnam County, at Phillipstown, and at several places on southwest side of Breakneck Mountain north of Cold Spring; Rockland County, Piermont, Stony Point, Round Island; Warren County, Glens Falls; Westchester County, Yonkers, Glenville, Scarsdale, and elsewhere.

Granite gneiss. Herkimer County, quarried at Little Falls for local use in riprap, concrete, etc.; Orange County, Cornwall; Putnam County, Carmel, used for buildings and monuments.

Granite-syenite. Clinton and Essex counties, quarried near Ausable Forks; Herkimer County, quarried at Little Falls.

Graphite (plumbago). Clinton County, occurs near Saranac River; Dutchess County, occurs south of Fishkill Landing; Essex County, has been mined at Bear Pond, town of Ticonderoga, 7½ miles southwest of Crown Point Center, and at Lead Hill, near Ticonderoga; Orange County, occurs at Duck Cedar Pond; Putnam County, occurs near Carmel; Saratoga County, mined at Conklingville and at Porter Corners, town of Greenfield; Warren County, mined at Graphite; Washington County, has been mined on South Bay, town of Dresden; Westchester County, occurs near Peekskill.

Gypsum. Found throughout central and western parts of State, in the Salina formation of the Silurian. Used for calcined plasters, agricultural plaster, and for admixture in Portland cement. Quarries in Cayuga County, at Union Springs; Erie County, Akron; Genesee County, Oakfield; Madison County, Canastota; Monroe County, Wheatland, Garbutt, and Mumford; Onondaga County, Jamesville, Fayetteville, Manlius, and Camillus; Ontario County, Victor and Port Gibson. Small quarries for local use at other places.

Hematite (red iron ore). Hematite associated with schists and limestone has been mined; Jefferson County, near Philadelphia, and Antwerp; St. Lawrence County, near De Kalb, Rossie, Hermon, and Somerville. Iron ore of Clinton formation outcrops through Herkimer, Monroe, Niagara, Oneida, Orleans, Oswego, and Wayne counties; mined at Clinton, Oneida County, and at Ontario, Wayne County.

Infusorial earth. Herkimer County, dug at Wilmurt; Suffolk County, occurs at Cold Spring Harbor.

Iron. *See* Brown iron ore, Hematite, and Magnetite.

Labradorite. Essex County, quarried for ornamental purposes near Keeseville.

Lead. *See* Cerusite and Galena.

Limestone (building). Limestones locally used for building; producing quarries in Albany, Cayuga, Clinton, Erie, Genesee, Greene, Jefferson, Lewis, Madison, Monroe, Montgomery, Niagara, Onondaga, Rensselaer, St. Lawrence, Schoharie, Seneca, Ulster, and Warren counties.

Limestone (crushed stone). Quarried in Albany County, at Ravena; Cayuga County, Auburn; Clinton County, Chazy and Plattsburg; Columbia County, on east outskirts of Hudson; Dutchess County, New Hamburg and Stoneco; Erie County, Depew, Lancaster, and elsewhere; Essex County, Westport; Fulton County, Mayfield; Genesee County, North Le Roy; Greene County, Catskill; Herkimer County, Jacksonburg and Jordanville; Jefferson County, Chaumont, Watertown, and near Clayton; Lewis County, small quantity at Lyon Falls; Madison County, Perryville and Blakeslee; Monroe County, Rochester; Montgomery County, Amsterdam and vicinity, and Cranesville; Niagara County, Lewiston, Lockport; Oneida County, Higginsville and Sauquoit; Orange County, Cedar Cliff; Onondaga County, East Onondaga, near Syracuse, Jamesville, and elsewhere; Ontario County, Canandaigua; Orleans County, Medina; Rensselaer County, Troy; Rockland County, Tompkins Cove; Saratoga County, Stillwater Center and near Saratoga; Schenectady County, Pattersonville; Schoharie County, Cobleskill and Schoharie; Seneca County, Waterloo and Seneca Falls; Ulster County, Kingston; Warren County, Glens Falls; Washington County, Sandy Hill, Smiths Basin, and Whitehall; Westchester County, Verplanck.

Limestone (flux). Quarried for flux in Cayuga County, at Auburn; Clinton County, Chazy; Erie County, Buffalo, Clarence, and Williamsville; Essex County, Port Henry; Genesee County, Le Roy; Niagara County, Pekin; St. Lawrence County, Gouverneur; Suffolk County, Greenport.

Limestone (lime). Burned in Albany, Cayuga, Clinton, Dutchess, Erie, Fulton, Genesee, Herkimer, Jefferson, Lewis, Monroe, Niagara, Onondaga, St. Lawrence, Ulster, Warren, Washington, Westchester, and other counties.

Limonite. *See* Brown iron ore.

Magnesite (carbonate of magnesia). Orange County, occurs at Warwick; Richmond County, Newdorp; Rockland County, Stony Point; Westchester County, near Rye and New Rochelle.

Magnetite (magnetic iron ore). Large deposits in Adirondack region. Principal producers are the Mineville, Port Henry, Lyon Mountain, Salisbury, and Benson mines. Workable bodies occur at many other places, as at Arnold mines, Clinton County. Lenticular ore bodies in gneiss mined in southeastern part of the State; Sterling Iron Co. and Lakeville & Hudson Iron Co., of Fort Montgomery, are the producers.

Marble. Clinton County, fossiliferous limestone has been quarried for ornamental work at Plattsburg and Chazy; Dutchess County, white marble quarried at South Dover; New York County, was formerly quarried at Kingsbridge and Tremont; Orange County, formerly quarried at Warwick; Oswego County, old quarries at Hastings and Sparta; Putnam County, was quarried at Towners Four Corners; St. Lawrence County, white, gray, and mottled marble are quarried at Gouverneur; Warren County, black marble is quarried at Glens Falls; Westchester County, is quarried at Tuckahoe.

Marl. Large deposits in Onondaga and Madison counties. Deposits also found in Albany, Columbia, Dutchess, Greene, Orange, Ulster, and Wayne counties; used as fertilizer. Cayuga County, occurs at Montezuma; Onondaga County, Warner; Steuben County, used for Portland cement at Wayland.

Menaccanite (titanic iron). Associated with gabbro-anorthosite intrusions in Clinton, Essex, Franklin, and Warren counties. Some attempts at smelting these ores have been made.

Mica (muscovite). Generally present in pegmatites, of which several have been listed under Feldspar. Essex County, obtained as by-product of feldspar mines at Crown Point, used for roofing; Orange County, found at Edenville; Saratoga County, suitable for grinding at Batchellerville feldspar quarry, and found at Greenfield; St. Lawrence County, has been mined near Oswegatchie; Westchester County, found at Pleasantville.

Millstone. Ulster County, Shawangunk conglomerate quarried at several localities.

Mineral paint. Manufactured from shales, iron ore, slate, and talc. Cattaraugus County at Randolph, from red shales of Chemung formation; Delaware County, red shales of Catskill formation at Roxbury; Oneida County, Clinton ore mined at Clinton; Otsego County, hematite at Oneonta; St. Lawrence County, hematite; Washington County, Cambrian red slate; Wayne County, Clinton hematite at Ontario.

Molybdenite. Clinton County, occurs at Lyon Mountain; Orange County, West Point and near Warwick; Putnam County, Tilly Foster mine; sparingly in granite.

Natural gas. Produced in 15 counties of the State. Principal fields in Allegany, Cattaraugus, Chautauqua, and Erie counties. The number of producing gas wells at the close of 1910 was 1,411.

Peat. Occurs in bogs of various sizes throughout the State. Some of the larger bogs are the Montezuma Marshes and Cowaselon Swamp, in central New York, and the Drowned Lands of the Wallkill, in southeastern New York. Nowhere utilized.

Petroleum. Productive horizon in Upper Devonian sandstones. The principal producing fields are Allegany County, Andover, Bolivar, Wirt, and other towns; Cattaraugus County, Allegany, Carrollton, and Olean townships. Erie and Steuben counties are minor producers.

Pyrite. Erie County, occurs along Eighteenmile Creek; Essex County, associated with graphite in Ticonderoga mines; Franklin County, in large bed at Duane; Jefferson County, with hematite in serpentine at Philadelphia, and with schist at Oxbow, Antwerp, and Keene station; Lewis County, at Martinsburg; Putnam County, Phillipstown, Patterson, and near Ludington Mill ; St. Lawrence County, with crystalline limestones, and schist, is mined at Hermon and Gouverneur; Sullivan County, with galena in Wurtsboro lead mine.

Pyrolusite. Cattaraugus County, small deposits near Randolph; Essex County, as coating on feldspar near Crown Point and Ticonderoga; Fulton County, in pegmatite near Northville; Saratoga County, in pegmatite at Corinth and Edinburg; Westchester County, in dolomite near Ossining.

Pyrrhotite. Large deposits, Jefferson County, at Oxbow; St. Lawrence County, at High Falls mine near Canton, and at Edwards; Westchester County, at Anthonys Nose.

Quartz. Essex County, has been quarried near Port Henry. Abundantly distributed in veins in the Adirondack region. Herkimer County, double-ended clear quartz crystals found in dolomite at Little Falls, sold for jewelry and curios; Washington County, quarried at Fort Ann; Westchester County, Bedford, for wood filler, paint, etc.

Rhodonite. Essex County, occurs near Keeseville.

Road metal. Albany County, limestone of the Helderberg group quarried at South Bethlehem; Rockland County, magnesian limestone quarried at Tompkins Cove, limestone and granite at Piermont and Iona Island; Schenectady County, sandstone at Duanesburg; Westchester County, granite and gneiss at Port Chester. Limestone and granite used at many localities in State. *See also* Trap.

Salt (brine). Pumped in Genesee County, at Le Roy; Livingston County, Piffard; Onondaga County, Tully, piped to Syracuse; Schuyler County, Watkins; Tompkins County, Ithaca and Ludlowville; Wyoming County, Rock Glen, Saltvale, and Silver Springs.

Salt (rock). Livingston County, mined at Cuylerville and Retsof.

Sand (building). Dug in Albany County, at Albany; Cayuga County, Auburn; Chautauqua County, Dunkirk and Fredonia; Broome County, Deposit; Cattaraugus County, Gowanda; Erie County, Buffalo, Clarence, and Lancaster;

Genesee County, Le Roy and Oakfield; Livingston County, near Mount Morris; Monroe County, Brighton, Pittsford, and Rochester; Nassau County, near Roslyn and at Port Washington; Onondaga County, Fairmont and Camillus; Ontario County, Fishers and Oaks Corners; Orange County, Otisville and Roseton; Oswego County, Fulton and Minetto; Rensselaer County, Rensselaer and Troy; Saratoga County, Cohoes and Waterford; Schenectady County, Rotterdam, Schenectady, and Scotia; Schuyler County, Watkins; Suffolk County, Northport; Ulster County, Marlboro; Washington County, Smiths Basin, and elsewhere; and in many other places.

Sand (glass). Dug in Oneida County, at Durhamville near Oneida Lake; Oswego County, Cleveland and Minetto; Schenectady County, Niskayuna; Ulster County, sandstone at Ellenville.

Sand (molding). Dug in Albany County at Cohoes, Delmar, Selkirk, and West Albany; Cayuga County, Auburn; Chautauqua County, Dunkirk; Dutchess County, Fishkill Landing; Erie County, North Collins; Greene County, Coxsackie; Oneida County, Boonville, Fish Creek, Forestport, and Rome; Oswego County, Fulton; Queens County, Rockaway Beach; Rensselaer County, Rensselaer; Saratoga County, Ballston, Burgoyne, Elnora, Jonesville, Round Lake, and Ushers; Schenectady County, South Schenectady; Wayne County, Sodus Point.

Sandstone. Quarried in Albany County, at Cohoes; Cayuga County, small quarries in Medina sandstone at Sterling; Chautauqua County, quarried at Jamestown; Dutchess county, Rhinebeck and Poughkeepsie; Essex County, Keeseville, on Ausable River, and Port Henry; Franklin County, near Burke; Greene County, New Baltimore and Catskill village; Herkimer County, sandstone of the Clinton formation quarried at Frankfort Hill; Madison County, quarried at Munnsville; Monroe County, Greece, and small quarries at Penfield and Brockport; Niagara County, Lewiston; Oneida County, New Hartford, Oriskany Falls, Washington Mills, and elsewhere; Orleans County, Albion, Fancher, Medina, and elsewhere; Oswego County, Granby and Oswego; Rensselaer County, intermittently quarried at Troy; Rockland County, Haverstraw and Nyack; St. Lawrence County, Hammond and Potsdam; Schenectady County, Craig, Duanesburg, and Schenectady; Washington County, Fort Ann; Wayne County, small quarries in Medina sandstone at Wolcott; Wyoming County, Arcade; Yates County, Himrod.

Sandstone (bluestone). Quarried in Albany County, at Voorheesville and South Berne; Allegany County, Belmont; Broome County, Cartersville, Deposit, and McClure; Cattaraugus County, Franklinville and South Olean; Cayuga County, King Ferry; Chautauqua County, Fredonia; Chenango County, Norwich and South Oxford; Delaware County, Deposit, Hancock, Lordville, and elsewhere; Greene County, Platt Clove and Tannersville; Otsego County, Cooperstown, Middlefield, Milford, and Oneonta; Sullivan County, Callicoon, Pond, Eddy, and Roscoe; Tioga County, Waverly; Ulster County, Allaku, Olive, number of quarries at Saugerties; Wyoming County, Warsaw, Rock Glen, and near Portageville; Yates County, Himrod, and elsewhere.

Serpentine. Occurs in Orange County, near Amity; Putnam County, Phillipstown; Richmond County, in large area on Staten Island; St. Lawrence County, Gouverneur, Fowler, Edwards, and Pitcairn Township; Warren County, Johnsburg and Warrensburg; Washington County, Shelving Rock, Lake George; Westchester County, near New Rochelle and Rye.

Siderite (spathic iron ore). Greene County, occurs near Catskill station; Columbia County, occurs at Linlithgo; Jefferson County, in hematite at Philadelphia and in crystals at Antwerp; Ulster County, Napanock, has been mined; St. Lawrence County, in serpentine rock northeast of Hermon.

Slate (roofing). Columbia County, occurs at New Lebanon; Rensselaer County, has been quarried near Hoosick; Washington County, quarried at Granville, Hebron, West Pawlett, and near Whitehall.

Sphalerite (zinc blende). Columbia County, with galena at Ancram lead mines; Herkimer County, Salisbury; Lewis County, Martinsburg and Lewisburg; Montgomery County, Flat Creek; Orange County, Phoenix lead-zinc mine near Otisville; St. Lawrence County, mined at Edwards, occurs in serpentine limestone at Balmat mine between Edwards and Gouverneur; Saratoga County, Saratoga Springs; Sullivan County, with galena at Wurtsboro; Ulster County, with galena at Ellenville and Red Bridge.

Spinel. Orange County, is found at numerous places; Westchester County, mined with corundum near Peekskill. Used as abrasive.

Strontianite. Schoharie County, in limestone near Schoharie.

Sunstone. Essex County, Crown Point; Westchester County, Horace Greely farm at Chappaqua.

Talc. Fibrous talc mined in Lewis County, near Natural Bridge; Richmond County, occurs with serpentine on Staten Island; St. Lawrence County, in towns of Fowler and Edwards. Used by paper, paint, and plaster manufacturers.

Trap. Unlimited supply in Palisades on lower Hudson River; Rockland County, quarried near Haverstraw, Mount Ivy, Rockland Lake, and West Nyack; Saratoga County, Greenfield. Used for road material, etc. Trap dikes are very numerous in the northern and eastern Adirondack region.

Verde antique. Essex County, occurs at Moriah, Port Henry, and Minerva; Warren County, Thurman.

Wad (earthy manganese). Columbia County, occurs at Austerlitz, Hillsdale, and Canaan Center; Dutchess County, small deposits at Unionvale; Essex County, near Keeseville; Lewis County, small deposits at Tug Hill near Houseville; Orange County, with iron ores near Warwick; also in Albany, Allegany, New York, Rensselaer, and Warren counties.

Zircon. Clinton County, found at Lyon Mountain; Essex County, occurs in few places near Crown Point and abundantly in pegmatite at Old Red mines, Mineville; Orange and St. Lawrence counties, occurs at numerous places.

NORTH CAROLINA.

Abrasive. *See* Corundum, Garnet, Millstone, and Novaculite.

Agalmatolite (pyrophyllite). In Algonkian rocks in a range crossing Chatham and Moore counties. Worked for use in wall paper, soaps, foundry.

Agate. Cabarrus County, near Concord and Harrisburg; Mecklenburg County, in small quantity; Orange County, moss agate near Hillsboro.

Allanite. Occurs in Henderson County, at zircon mines, near Zirconia; Iredell County, abundant near Bethany Church; Madison County, at Democrat; Mitchell County, Wiseman mica mine.

Almandite. *See* Garnet.

Amethyst. Iredell County, at several localities southeast of Statesville; Lincoln County, at Lincolnton; Macon County, in veins cutting gneiss at several places in valley of Tessentee Creek, near Scaly Mountain, and south of Highlands; Wake County, near Raleigh; Warren County, near Warrenton.

Aquamarine. Alexander County, mined at Hiddenite and Ellis mines, near Hiddenite; Burke County, has been found in South Mountain; Jackson County, mined several miles south of Cashiers; Macon County, mined at head of Tessentee Creek; Mitchell County, mined at Wiseman and other mica mines; Yancey County, in Roy and other mica mines.

Arsenopyrite (mispickel). Cleveland County, mined for gold at Kings Mountain mine; occurs also in gold mines in Cabarrus, Gaston, Union, and Watauga counties, but only sparingly with other ores.

Asbestos. Burke County, occurs near Brindletown and Warlicks Mills; Caldwell County, near Baker mine; Jackson County, southern part; fine and fibrous; Macon County, Nantahala River; Mitchell County, near Bakersville; Wilkes County, near Wilkesboro and Brushy Mountains; and in many other localities.

Auerlite. Henderson County, at zircon mine, in pegmatite 2 miles west of Zirconia.

Azurite (blue carbonate of copper). At copper mines in Cabarrus, Chatham, Gaston, Granville, Mecklenburg, and Moore counties, in small quantity.

Barite. Principal deposits are: Gaston County, about 5 miles south from Bessemer City and in a belt extending southwest parallel with Kings Mountain Ridge; and in Madison County, near Hot Springs, Marshall, Sandy Bottom, and Stackhouse. Has also been mined in Orange County, at Hillsboro.

Beryl. Alexander County, mined at hiddenite-emerald mine; Burke County, near Burkmont in South Mountains; in mica mines in Alexander, Iredell, Mitchell, and Yancey counties. *See also* Aquamarine.

Bornite (purple copper ore). Cabarrus, Rowan, and Stanley counties, with chalcocite in Gold Hill district; Granville and Person counties, important ore in quartz gangue in Virgilina district, mined for copper. Occurs also in Alleghany County, Peach Bottom mine; Ashe County, Gap Creek mine; Chatham County, Clegg's mine; Guilford County, Gardiner Hill mine.

Brown iron ore (limonite, bog iron ore). Many deposits in eastern part of State, in Duplin, Jones, Nash, New Hanover, Pender, and other counties.

Brown iron ore (brown hematite). Ashe County, has been mined in upper part of Ore Knob copper mines, accompanying copper lodes; Burke County, many beds in a northeasterly direction from Jacobi Fork of Catawba River to Brushy Mountains in Wilkes County; large beds in Chatham County, at Ore Hill; Cherokee County, at Nottla, and along Valley River; Gaston County, Highshoals; Johnston County, near Smithfield; in Lincoln and Catawba counties; McDowell County, has been mined in Linville Mountains. Many localities have been worked in Buncombe, Burke, Caldwell, Gaston, McDowell, Mitchell, Surry, Watauga, and other counties.

Cassiterite (tin ore). Tin belt extends from southeastern part of Cleveland County, through western part of Gaston County, to about 4 miles east of Lincolnton, Lincoln County. Cleveland County, has been mined at Jones, Foster, and Fairies mines near Kings Mountain; and in Lincoln County, near Lincolnton.

Cement material. Crystalline limestones in western part of State, and soft limestones in Eocene and Miocene in eastern part of State suitable for cement.

Cerusite (lead carbonate). Caldwell County, Baker mine; Cherokee County, Murphy; Davidson County, Silver Hill, with galena and silver ores; Rowan County.

Chalcanthite (blue vitriol, hydrous copper sulphate). Cleveland County, secondary mineral at Kings Mountain mine, mined for gold.

Chalcocite (copper glance). Cabarrus, Rowan, and Stanley counties, with bornite in Gold Hill district; Person and Granville counties, mined for copper in Virgilina district. Found also in Ashe County, at Ore Knob mine and Gap Creek mine; Cabarrus County, Pioneer Mills mine; Jackson County, Way Hutta and Wolf Creek mines; Swain County, Nichols.

Chalcopyrite. Ashe County, found in Ore Knob mine; Alleghany County, Peach Bottom mines; Chatham County, Clegg mine; in mines of Davidson, Gaston, Guilford, Mecklenburg, Rowan, and Union counties; Guilford County, Gardiner Hill mine; Haywood and Jackson counties, has been mined in Way Hutta, Cullowhee, Savannah, and other mines in copper belt; Lincoln County, Macpelah Church; Orange County, near Hillsboro and Chapel Hill; Wake County, near Raleigh; Watauga County, Elk Knob and Gap Creek mines.

Chalcopyrite (auriferous). Rowan County, Gold Hill district, principal copper ore.

Chromite. Buncombe County, near Democrat and Stocksville; Jackson County, at many places in vicinity of Webster, between Willets and Balsam Gap; Yancey County, in vicinity of Burnsville, has been mined and shipped from Mine Hill.

Chrysocolla (silicate of copper). Found in many copper mines in western part of State.

Clay (brick). Bricks are made from local clay pits at one or more localities in 67 counties out of the 98 in the State. Product in 1910 valued at more than $1,000,000.

Clay (fire). Semirefractory and siliceous clays mined for fire brick in Buncombe County at Emma; Cleveland County, Grover; and Guilford County, Pomona.

Clay (kaolin). Jackson County, dug near Webster; Macon County, near Franklin; Mitchell County, on Bear Creek near Penland; Swain County, at Almond and near Bryson City; occurs in decomposed pegmatite veins in Smoky Mountain region in western part of State.

Clay (pottery). Mined in Buncombe County, at Luthers; Burke County, at Morganton; Gaston County, Mount Holly; Lincoln County, Henry and Lincolnton; Randolph County at Whynot Academy; also mined in Chatham, Johnston, Moore, Union, and Wilkes counties.

Coal. Dan River area, in Triassic rocks: Carbonaceous shale outcrops from Germanton, Stokes County, to Leaksville, Rockingham County; semianthracite was mined near Leaksville; beds too thin, irregular, and small in extent to be of value. Deep River area: Chatham and Moore counties, in Triassic rocks; bituminous 3 feet thick, was formerly mined at Cumnocks.

Columbite. Occasional pieces found in Mitchell County, at Wiseman and other mines near Spruce Pine; Yancey County, at Ray mine and elsewhere.

Corundum. Alexander County, mined to limited extent at Acme mine, near Statesville; Clay County, in peridotite in Buck Creek, Herbert, and other mines; Jackson County, considerable quantity at Sapphire mine, abrasive; Macon County, in Corundum Hill mine near Franklin, and in Mincey mine 2 miles northwest of Corundum Hill; Madison County, at the Carter mine, near Democrat; Transylvania County, good quality in peridotite at Burnt Rock mine; Yancey County, with magnetite, menaccanite, and staurolite, near Burnsville.

Corundum (emerald, oriental). Found sparingly in Clay County, at Cullakeenee mine, Buck Creek near Elf; Macon County, Corundum Hill mine. Pink corundum in green amphibolite, decorative stone.

Corundum (emery). Guilford County, occurs at McChristian Place, 7 miles south of Friendship; Macon County, has been mined at Fairview mine near North Skeener Gap, for abrasive; mined sparingly at several places south of Franklin; Mitchell County, near Bakersville.

Corundum (ruby). Mined in Jackson County, Montvale; Macon County, at Corundum Hill mine, Cullasaja, Caler Fork of Cowee Creek.

Corundum (sapphire). Clay County, few found near Elf; Jackson County, Sapphire and Whitewater mines near Sapphire; Macon County, Corundum Hill mine.

Cuprite (red oxide of copper). Sparingly in copper mines of Alleghany, Ashe, Caldwell, Chatham, Guilford, Jackson, Swain, Lincoln, and Mecklenburg counties.

Cyanite. Mitchell County, summit of Yellow Mountain; Yancey County, green cyanite at north end of Black Mountains.

Cyrtolite. Henderson County, at Zirconia; Mitchell County, in pegmatites near Sprucepine.

Diamond. Ten authentic diamonds have been found in the State: Burke County, 2 at and near Brindletown Creek ford; Franklin County, 2 from Portis mine; Lincoln County, Cottage Home; McDowell County, headwaters of Muddy Creek, and near Dysartville; Mecklenburg County, Todds Branch; Rutherford County, Twitty's mine.

Emerald (beryl). Alexander County, Hiddenite mine, near Hiddenite; Cleveland County, Turner mine 5 miles southwest of Shelby; Mitchell County, Crabtree Mountain. *See also* Corundum (emerald).

Feldspar. Mitchell County, quarried at Penland. Found in nearly all mica mines of Mitchell and Yancey counties.

Galena. Cabarrus County, McMakin and other mines; Cherokee County, with gold ores, Murphy; Cleveland County, mined for gold at Kings Mountain mine in southern part of county; Davidson County, has been found at Silver Hill, with blende, native silver, etc.; Gaston County, with blende in Causler, Shuford and Long Creek mines; Randolph County, Hoover and Boss mines; Rowan County, Gold Hill district, for gold and silver; Union mine and others; Union County, Long mine; Watauga County, Beech Mountain, several localities; Wilkes County, Flint Knob; other localities in Alleghany, Burke, Caldwell, Chatham, Macon, Montgomery, Surry, Swain, and Union counties.

Garnet. Burke County, abrasive and gem formerly mined 8 miles southeast of Morganton, along Laurel Creek; Jackson County, abrasive, mined at Sugar Loaf Mountain, near Willets; Madison County, abrasive, mined at Marshall.

Garnet (rhodolite and almandite). Macon County, obtained with corundum and ruby near In Situ Hill, on Cowee Creek, and on Mason Branch, 5 miles north of Franklin.

Gneiss. Alexander County, ornamental stone at Rocky Face Mountain; Watauga County, Blowing Rock; not quarried.

Gold. There were 22 placer mines and 9 deep mines operating in 1911; production was valued at $70,282. Burke County, principal production from placers near Bridgewater and Brindletown; Cabarrus County, from reworking dump of old Phoenix mine; also Gorman, Saunders, McMakin, and Reed mines; Catawba County, Catawba and England mines; Cherokee County, Middle branch of Tathams Creek, near Andrews; Cleveland County, has been recovered as by-product in mining for monazite; Davidson County, several mines in Cid mining district; no production; Franklin County, in 1910, small amount produced at Portis mine; Gaston County, Kings Mountain and Burrell-Wells mines; Granville County, Blue Wing and Copper King mines were idle in 1911; Jackson County, Cullowhee mine; no gold reported in 1911; Macon County, small amount from placer near Flats; McDowell County, small amount from placer near Marion, Dysartville, and Vein Mountain; Mecklenburg County, Catawba River dredge near Charlotte and Surface Hill hydraulic mines; Montgomery County, Iola mine near Candor, most important producer in State, 650-foot vertical shaft, and 450-foot incline shaft; small production from Old Coggin, Uwharra (old Montgomery), Martha Washington, and Golconda mines; Moore County, small prospects near old Cagle mine; Nash County, small output from Mann-Arrington mine; gold ore found in several prospects near Nashville; Orange County, small yield from North State placer; Polk County, Double Branch mine has five shafts; Randolph County, Scarlett, Talbert, Ashboro, Redding, and Southern Homestake mines; Rowan County, mines in Gold Hill district made small yield in 1911, mainly from old dumps; the Steele placer near Cleveland was a producer; Union County, Bonnie Doon and other mines near Indian Trail made considerable output in 1910.

Granite. Thirty-five quarries operating in 1910 produced granite valued at $839,742; located in the following places: Buncombe County, near Asheville; Davie County, Lexington; Henderson County, Balfour; Mecklenburg County, near Charlotte; Polk County, Rockliff; Rockingham County, Ruffin; Rowan County, at Faith; large quarry at Salisbury; Surry County, Mount Airy, very large quarry; Vance County, Greystone; Wake County, near Raleigh; Warren County, 1 mile northwest of Wise siding; Wilson County, Elm City; also in Anson, Gaston, and McDowell counties; and small quarries, to supply local demand, have been opened at many other places in western part of State.

Graphite. Amorphous; has been mined in Alexander County, at Taylorsville; Cleveland County, at Kings Mountain mine; Haywood County, Waynesville; McDowell County, Graphiteville; Wake County, Method; and in Yancey County. Impure beds in gneiss in Catawba, Cleveland, Gaston, Lincoln, and Rutherford counties; opened near Catawba station, Catawba County.

Gummite. Mitchell County, Penland, Sprucepine, and other places.

Halite. *See* Salt.

Hematite. Has been mined in Chatham County, Ore Hill; Gaston County, Ormond mine; Harnett County, Buckhorn mine.

Hiddenite (spodumene). Alexander County, gems mined in veins in biotite gneiss at Hiddenite; associated with aquamarine and emerald.

Lignite (brown coal). Common in marl beds in the eastern counties; in Triassic rocks in Anson County, on Brown Creek; Granville County, on Tar River.

Limonite. *See* Brown iron ore.

Limestone. Produced mainly for burning into lime, and for road metal. Quarries, in 1910 in Craven County, at Newbern; Henderson County, at Fletcher and Hendersonville; Transylvania County, Brevard. Has been quarried in Beaufort, Buncombe, Jones, and New Hanover counties. Other localities known in Cleveland, Gaston, Lincoln, and Stokes counties.

Magnetite (magnetic iron ore). Occurs in pre-Cambrian formations in central and western parts of State, at many localities. Mined for iron at Cranberry, Mitchell County. Has been mined in Ashe, Caldwell, Cleveland, Gaston, Stokes, Surry, and other counties.

Malachite (green copper carbonate). Occurs in small quantity in copper mines in western part of State.

Manganese ore. Caldwell County, reported from west of Lenoir; Chatham County, manganiferous iron ore occurs at the Buckhorn iron mine; Cleveland County, small veins and replacements in schists in Kings Mountain region; belt extends northeast into Catawba and Lincoln counties; Surry County, north of Dobson, manganiferous garnet.

Marble. Cherokee County, quarried at Murphy. Occurs also in McDowell, Mitchell, and Swain counties.

Marl (calcareous). Occurs in limited patches in all the eastern counties throughout an area equal to one-fourth of State. Used locally in many places.

Marl (greensand or glauconitic). Occurs in southeastern counties, from Neuse River to Cape Fear River.

Melaconite (black oxide of copper). Occurs sparingly in copper mines in western part of State.

Menaccanite. Caldwell County, was prospected north of Lenoir.

Mica (muscovite). Deposits have been opened in 18 or more counties in the western part of State, where the production of mica is an important industry. Has been mined and prospected extensively; probably have been over 100 good producing mines. Ashe County, near Jefferson, Beaver Creek, and Elk Crossroads; Buncombe County, near Balsam Gap, Black Mountain, Montreat, along the North Fork of Swannanoa River; Burke County, near Burkemont, in South Mountains; Cleveland County, in Indian Town region and near Casar; several miles northwest of Shelby, near Belwood; Gaston County, in northwestern part of county; Haywood County, in Allen Creek basin south of Waynesville, and in Balsam Mountains, at head of Pigeon River; Jackson County, a large number of mines in a belt several miles wide, extending northeast across the county from Cowee Bald and Moss Knob, on the Cowee Mountain divide, to Balsam Gap and Richland Balsam Mountain; also near Sols Creek, along Tuckasegee River, near Pinhook Gap, Wolf Mountain, and at several places in southeastern corner of county; Lincoln County, in belt along west side of county; Macon County, in a belt several miles wide, extending northeast across county, from Nantahala River over Wayah Mountain to Cowee Bald and Moss Knob, on the Cowee Mountain divide; also near Higdonville, Scaly, and Highlands; Mitchell County, large number of mines in region between Bakersville, Crabtree Creek, Blue Ridge Mountain, Lineback, and Cranberry; Sprucepine central point to mica region; Rutherford County, Isinglass Hill, 3½ miles north of Rutherfordton, and other localities; Stokes County, near Sandy Ridge; Transylvania County, Bee Tree Fork region and near Sapphire; Watauga County, north of Boone and 2 miles northwest of Elk Crossroads; Yancey County, many mines along South Toe River and westward across Black Mountains, near Burnsville and Green Mountain.

Millstone. Anson County, sandstone used as grindstones during the Civil War; Madison County, quartzite on Laurel River, used for millstone; Moore County, Triassic conglomerates, used for millstone, McLennans Creek; Rowan County, made from granitic rock at Salisbury.

Monazite. Found in gravels in area of about 3,000 square miles. Produced from placers in Burke County, at Bridgewater, Brindletown, Connellys Springs, and Morganton; Cleveland County, Belwood, Casar, Lawndale, Carpenters Knob region, Mooresboro, and elsewhere; Gaston County, Cherryville; Iredell County, north of Statesville; Lincoln County, western part; Madison County, in masses up to 60 pounds in weight near Mars Hills; Rutherford County, Ellenboro, Oak Springs, Rutherfordton, and elsewhere; also in Alexander and Catawba counties.

Nagyagite. Cleveland County, mined for gold at Kings Mountain mine.

Novaculite (whetstone). Anson County, has been quarried near Wadesboro; Orange County, few miles west of Chapel Hill, quarried extensively; Person County, near Roxboro.

Peat. Abounds in the eastern part of State, particularly in the seaboard counties; not used.

Pitchblende. *See* Uraninite.

Platinum. A belt of platinum-bearing rock is reported extending from Cedar Falls, N. C., to Danville, Va.

Polycrase. Henderson County, in gold washings with zircon, magnetite, etc., near Zirconia.

Psilomelane. Caldwell County, in gneissic rocks near Lenoir; Chatham County, with iron ore at Buckhorn iron mine; Gaston County, in schist 1 mile southeast of Kings Creek.

Pyrite. Cleveland County, mined for gold at Kings Mountain mine; Gaston County has been mined as sulphur ore 5 miles north of Bessemer City; Rowan County, mined for gold in Gold Hill district; and Union County, Colossus.

Pyrolusite (black oxide of manganese). Chatham County, with iron ore at Buckhorn iron mine; Gaston County, in schist 1 mile southeast of Kings Creek; and elsewhere in small quantity.

Pyrophyllite. Moore County, produced by three mines at Glendon for use as talc.

Pyrrhotite (magnetic pyrites). Plentiful, generally with pyrite and chalcopyrite in copper deposits in Ashe, Jackson, Macon, and Swain counties. Cleveland County, mined for gold at Kings Mountain mine; Macon County, occurs in gravels of corundum mines.

Quartz (quartzite). Cherokee County, quarried near Ranger for flux in copper smelting, and in blocks as filler for acid towers; Gaston County, mined at Oliver mine.

Ruby. *See* Corundum.

Rutile. Clay County, in placer on Shooting Creek east of Hayesville; Macon County, abundant with corundum in gravels of Mason Branch and Caler Fork of Cowee Creek; fine specimens in Alexander and Iredell counties.

Rhodolite. *See* Garnet.

Salt (brine). Buckingham, Chatham, and Orange counties, formerly obtained from wells in Triassic beds.

Samarskite (yttria ore). Mitchell County, large masses have been found at Wiseman mica mine; sparingly at other mica mines.

Sand and gravel. Dug at following places: Anson County, Lilleville; Buncombe County, Asheville; Cleveland County, Shelby; Gaston County, Bessemer City; Guilford County, Greensboro; Henderson County, Balfour; Iredell County, Statesville; Mecklenburg County, Charlotte; Moore County, West End; Wilkes County, North Wilkesboro.

Sandstone. Only quarry operating is at Sanford, Lee County. Idle quarries in sandstone of Triassic period in Anson County, at Wadesboro; Chatham County Chatham, near Egypt; Orange County, near Durham; Rockingham and Stokes counties, quarries in the Dan River belt.

Sapphire. *See* Corundum.

Serpentine. Very fine, dark-colored, takes fine polish; Buncombe County, Asheville; Caldwell County, Baker quarry; Clay County, Buck Creek; also in Forsythe and Wake counties; yellowish-green variety occurs in Caldwell, Orange, Stokes, Surry, Wake, Wilkes, and Yancey counties.

Siderite (black band ore and ball ore). Chatham County, beds in Triassic rocks of Deep River opened at Egypt, Farmville, and Gulf; occurs also in Davidson, Granville, and Halifax counties; common as gangue material in gold mines, also at some copper mines.

Silver. Recovered in refining gold and copper, produced mainly in Person and Rowan counties. Native silver at Silver Hill and Silver Valley mine, Davidson County.

Soapstone. Many undeveloped masses in western part of State; Ashe County, probable valuable deposits 2 miles west of Beaver Creek, quarried for local use.

Sphalerite (zinc blende). Cabarrus County, in McMakin mine with galena and silver ores; Cleveland County, mined for gold in Kings Mountain mine in southeastern part of county; Davidson County, has been found at Silver Hill with galena and silver ores; McDowell County, in Dobson mine, Cedar Grove, in limestone; Rowan County, small quantity in Gold Hill district; Union County, Lemmon, Long, Moore, and Stewart gold mines; in small quantities in Alleghany, Gaston, Macon, Madison, and Montgomery counties.

Spinel. Macon County, found in gravels in Cowee Valley; Mitchell County, gahnite variety in Chalk Mountain and other mica mines.

Spodumene. *See* Hiddenite.

Staurolite. Good single and double crossed crystals, have some commercial value as curios; found in Ashe County; Burke County, South Mountains; Cherokee County; Haywood County, near Waynesville; Iredell County, Belts Bridge;

Macon County, near Corundum Hill; northern part of Wake County; and in many places west of Blue Ridge.

Sunstone. Iredell County, near Statesville.

Talc. Six companies producing in 1911. Most of the product came from Swain County. Mined in Alleghany County, near Piney Creek; Cherokee County, was formerly mined at Tomotla; Jackson County, mined at Beta; Moore County, three mines at Glendon mining pyrophyllite; Swain County, mined at Hewitts.

Tedradymite. Burke, Cabarrus, Gasto, and McDowell counties, in minute scales at copper mines; Davidson County, occurs in Allen mine and in Beck's mine west of Silver Hill; Montgomery County, mined for gold at Asbury mine.

Tetrahedrite. Cabarrus County, has been found in McMakin mine with silver, zincblende, and galena, and in Sudwick mine with copper pyrites; Cleveland, mined for gold at Kings Mountain mine.

Tin. *See* Cassiterite.

Tourmaline. Alexander County, black crystals at Stony Point; Yancey County, at Ray mine; and at many other localities.

Uraninite (pitchblende). Mitchell County, in Flat Rock mine, in Deake mine, in a feldspar quarry near Penland, and in Wiseman mica mine.

Uranophane. Mitchell County, Penland, Sprucepine, and other places.

Xenotime (yttrium phosphate). Burke County, from gold washings at Brindletown.

Zircon. Burke, McDowell, and Rutherford counties, in gravels of monazite mines; Henderson County, mined near Zirconia; Iredell County, occurs near New Sterling.

NORTH DAKOTA.

Cement material. Cretaceous limestone used for natural cement in Cavalier County, about 10 miles north of Milton; Pembina County, quarried and mined along Tongue River. Niobrara chalk suitable for Portland cement occurs in State, but is almost entirely concealed by glacial drift and Pierre shale.

Clay (brick). Dug in Bottineau County, at Halls Spur 3 miles north of Omemee and at Arnedo; Bowman County, Scranton; Burleigh County, Bismarck and Chapin; Cass County, south of Fargo; Cavalier County, Mayo; Grand Forks County, Grand Forks; McLean County, Wilton, and 6 miles west of Coal Harbor; Morton County, Mandan and Hebron; Pembina County, Drayton and Mayo, near Walhalla; Stark County, Dickinson and Richardton; Ward County, Burlington, Kenmare, and Minot; Traill County, half a mile north of Hillsboro; Williams County, Williston.

Clay (fire). Morton County, good quality, used near Hebron; and in Stark County, at Dickinson.

Clay (pottery). Clay suitable for stoneware occurs in Billings County, near Sandcreek post office; Burleigh County, along Missouri River at Bismarck; Cavalier County, near Olga; Dunn County, near Oakdale; Morton County, near Hebron; Stark County, near Dickinson and Gladstone; and at other localities.

Coal (lignite). Extensive beds in Cretaceous and Tertiary formations underly western half of State. Production in 1911 was 502,628 short tons. Principal mines and outcrops are in following counties: Adams County, four mines in vicinity of Haynes work a 12-foot bed; Billings county, vicinity of Yule, Great Bend, Medora, Sentinel Butte, East Rainy Buttes, and numerous other localities; mined at Medora, near Sentinel Butte, and elsewhere; Bowman County, outcrops along North Fork of Grand River, in southeastern part of county, also on Coyote Creek, mined 2 miles west of Haley and at Scranton; Burleigh County, McClelland mine, 7-foot bed, excellent quality; Washburn mine, near Wilton, largest in State; Emmons County, near Livona, 2½-foot bed, mined at Edick and Parkhurst mine; Hettinger County, outcrops at number of points on Coal Bank Creek, 8 miles south of New England, and in the southeastern corner of the county; small quantity mined for local use; McLean County, outcrops along banks of Missouri River, 30 miles above Bismarck; Satterlund mine, 6 miles northwest of Washburn, 9–10 foot bed, local use; Rose Hill mine, 5-foot bed; Coal Harbor district, Marion, Joe Mann, and Eakes mines, bed 7 feet 9 inches; Dogden Buttes, 16-foot bed; near Turtle Lake, 7–9 foot bed; Mercer County, along Missouri River near Mannhaven, 7-foot bed; also above and below Hazen, and in Big Bend district; Morton County, along valley from Sims to New Salem; mined at New Salem, 6-foot bed, also mined in vicinity of Sims (Feland mine), Glen Ullin, and Hebron, and at many localities south of railroad; Oliver County, abundant beds on east bank of Missouri River and at Square Butte Creek, and branches of Knife River, 6–7 foot bed; mined by stripping, 3 miles south of Hensler; also mined in southern part of county; Rolette County, on southern slope of hills near Dunseith, 3–4 foot bed, mines reopened; Stark County, extensively mined near Lehigh, 10–15 foot bed; abundant about Belfield, mined on south side of Heart, 6-foot bed, excellent; Ward County, along edge of bluffs of Des Lacs River to prairie; mined near Burlington, 9–13 foot bed; near Kenmare, 6-foot bed, Smith-Kenmare, Diamond, and many other mines; Williams County, considerable deposit about Williston along Missouri River, mined for local supply; workable beds occur also in Adams, Burke, Divide, Dunn, McKenzie, Mountrail, and Renville counties.

Granite. Large drift bowlders are abundant in all the counties of North Dakota, except Adams, Billings, Bowman, and Hettinger counties; used locally for building material.

Natural gas. Bottineau County, 12 wells in sand underlying drift of Lake Souris; gas piped to Westhope and Lansford, for local use; Lamoure County, some gas produced from 7 artesian wells; Renville County, in blue clay and shale near Mohall, 2 wells, local use.

Road metal (sand and gravel). Dug in Grand Forks County, at Emerado Beach; Hettinger County, at Liberty; Pembina County, in Fremont Township and Walhalla; Walsh County, in "The Mountains" in Herman and Norcross beaches in vicinity of Edinburg; and in many other places; along ancient shore lines of Lake Agassiz in Cass, Grand Forks, Pembina, Walsh, and Traill counties.

Sand (building). Small quantity dug for local use.

Sandstone. Emmons County, quarried at Linton; McLean County, along Missouri River at Washburn; McHenry County, near Velva; Stark County, small quantities have been quarried at Dickinson.

OHIO.

Bromine. Meigs County, distilled from brines at Pomeroy and Minersville.

Brown iron ore (limonite). Occurs in form of concretions known as "kidney ore," in thin beds as "block ores," and as "limestone ores." The "Lower Coal Measures," "Barren Measures," and "Upper Coal Measures" contain the ore-bearing horizons. Carroll, Columbiana, Gallia, Hocking, Jackson, Lawrence, Licking, Mahoning, Muskingum, Perry, Scioto, Trumbull, and Vinton counties have produced ore from these horizons; of little economic importance at present time.

Celestite (strontium sulphate). Lucas County, with calcite, at Whitehouse, and with gypsum at West Sister Island; Ottawa County, Green or Strontian Island, Put-in-Bay, Lake Erie, in fine crystals and in large masses, filling fissures in the water-lime rock.

Cement (natural). Columbiana County, at Lisbon; Defiance County, Devonian calcareous shale used at Defiance.

Cement material (Portland). Ferruginous limestone and shale used in Lawrence County, at Ironton and Superior; and Stark County, at Middlebranch. Marl and clay used in Erie County at Baybridge and Castalia; Logan County, at Rushsylvania.

Cement (puzzolan). Mahoning County, manufactured at Struthers.

Clay (brick). Widely distributed; used at one or more places in every county of the State.

Clay (fire). Abundant in State; mined in Athens County, at Nelsonville; Columbiana County, East Liverpool and Washingtonville; Hamilton County, Delhi; Hocking County, East Clayton; Jackson County, Oak Hill; Jefferson County, Empire and Irondale; Lawrence County, Ironton and Steece; Morrow County, near Sparta; Muskingum County, South Zanesville and small quantity at Ellis Station; Perry County, small quantity at Chalfants; Scioto County, Lilly and Sciotoville; Stark County, Beach City, Massillon, and 1½ miles south of Magnolia, very small quantity at Limaville, also sagger clay at North Industry; Vinton County, sagger clay mined at Richland; Washington County, Newport.

Clay (pottery and tile). Clays and shales extensively mined in Columbiana County, at East Liverpool; Darke County, Palestine; Hamilton County, in Springfield Township; Hocking County, at Haydenville and in very small quantity near Logan; Jefferson County, Steubenville; Licking County, Hanover; Lorain County, Elyria; Muskingum County, Zanesville; Perry County, Crooksville and Roseville; Stark County, extensively mined at Canton and North Industry; Wayne County, very small quantity at Dalton.

Coal (bituminous). The Sharon, Wellston, Lower and Middle Kittanning, Upper Freeport, Pittsburg, Pomeroy, and Meigs Creek coal beds extensively mined in eastern part of the State in Athens, Belmont, Carroll, Columbiana, Coshocton, Gallia, Guernsey, Harrison, Hocking, Holmes, Jackson, Jefferson, Lawrence, Mahoning, Medina, Meigs, Morgan, Muskingum, Noble, Perry, Portage, Scioto, Stark, Summit, Trumbull, Tuscarawas, Vinton, and Wayne counties. Athens, Belmont, Guernsey, and Jefferson counties each produced more than 3,000,000 tons in 1911; the total output of the State was 30,759,986 tons in 1911.

Flagstone. Allen County, quarried in Lima; Clarke and Greene counties; Cuyahoga County, formerly quarried at Berea; Geauga County, Thompson; Highland County, from "Helderberg" limestone at Greenfield; Logan County, Belle Center; Lorain County, Amherst and Lagrange; Preble County, Eaton; Trumbull County, magnesian limestone at Warren. Scioto valley, sandstones of the Waverly group.

Grindstone. Has been quarried in Cuyahoga County, at Berea, Chagrin Falls, Independence, South Park, and West View; Erie County, Berlin Heights; Harrison County, Tippecanoe; Jefferson County, Empire; Lorain County, North Amherst, Elyria, Oberlin, and elsewhere; Scioto County, Portsmouth; Stark County, Massillon; Summit County, Peninsula; Washington County, Belpre, Briggs, Constitution, Marietta, and vicinity.

Gypsum. Occurs in various places in the "Helderberg," encountered in most of deep wells in north and central Ohio; Ottawa County, quarried near Gypsum Station and Port Clinton.

Hematite (fossil ore, dyestone). Occurs in Clinton County, at Todds Ford, near Wilmington; Highland County, at Sinking Springs, most important deposit of this ore in State· Muskingum County, near Zanesville.

Lignite. *See* Coal.

Limestone (building). Quarried in Allen County, at Bluffton, Delphos, Elida, and Lafayette; Butler County, near Hamilton; Clark County, Springfield; Clermont County, Williamsburg; Clinton County, Wilmington; Delaware County; Erie County, Castalia and Sandusky; Franklin County, Columbus and Marble Cliff; Greene County, Xenia and New Jasper; Hamilton County, Cincinnati and Glendale; Hancock County, Arlington and Findlay; Highland County, Highland; Huron County, Bellevue; Logan County, Belle Center and Bellefontaine; Lucas County, Whitehouse; Marion County, Marion; Miami County, Covington and Ludlow; Montgomery County, Brookville and Dayton; Preble County, Eaton and Lewisburg; Putnam County, Cloverdale, Ottoville, Pandora, and Rimer; Sandusky County, Fremont; Seneca County, Bloomville, Flat Rock, and Tiffin; Wood County, Lime City and Bowling Green.

Limestone (crushed stone). Carboniferous, Silurian, and Devonian limestones widely distributed except for barren area extending in a north-south direction in the central part of the State. Used extensively in Allen, Butler, Clark, Clay, Clermont, Clinton, Columbiana, Crawford, Delaware, Erie, Franklin, Greene, Hamilton, Hancock, Hardin, Highland, Lawrence, Logan, Lucas, Mahoning, Marion, Mercer, Miami, Montgomery, Ottawa, Paulding, Preble, Putnam, Ross, Sandusky, Seneca, Van Wert, Wood, and Wyandot counties.

Limestone (flux). Used as flux in iron and copper smelters and in the manufacture of glass. Quarried in Clark County at Cold Springs and Springfield; Crawford County, Bucyrus; Franklin County, Columbus and Marble Cliff; Lawrence County, Bartles Station, Blackford, Eifort and Ort; Lucas County, Silica; Mahoning County, Lowellville; Marion County, Marion; Miami County, Piqua; Ottawa County, Marblehead.

Limestone (lime). Burned in Belmont County, West Wheeling; Clark County, at Cold Springs and Springfield; Crawford County, Oceola; Delaware County, Delaware and Radner; Erie County, Kellys Island; Greene County, Cedarville; Hamilton County, Cincinnati; Hardin County, Patterson; Harrison County, Germane; Highland County, Greenfield and Hillsboro; Logan County, Middleburg; Marion County, Marion; Mercer County, Fort Recovery; Miami County, Covington; Montgomery County, near Dayton; Ottawa County, Clay Center, Genoa, and Marblehead; Preble County, New Paris; Sandusky County, Fremont and Woodville; Seneca County, Fostoria and Tiffin; Stark County, Marlboro and elsewhere; Wood County, Luckey and Sugar Ridge; Wyandot County, Casey.

Limonite. *See* Brown iron ore.

Marl. Erie County, used for Portland cement in Baybridge and Castalia; Fulton and Williams counties, occurs in lakes and marshes; Highland County, a marly magnesian limestone at Sinking Spring; Logan County, a marly magnesian limestone at Rushsylvania; Preble County, Camden; Summit County, Hudson; Sandusky County, dug in lakes and marshes.

Natural gas. The "Trenton," "Clinton," "Helderberg," and Berea are the producing horizons. Many wells are located in Ashland, Ashtabula, Athens, Auglaize, Belmont, Carroll, Columbiana, Cuyahoga, Darke, Fairfield, Guernsey, Hancock, Hardin, Harrison, Hocking, Holmes, Jefferson, Knox, Lake, Licking, Logan, Lorain, Lucas, Medina, Mercer, and Monroe counties.

Oilstones. Cuyahoga County, quarried at Chagrin Falls.

Peat. Lake County, near Painesville; Lorain County, Brighton and Camden; Summit County, large deposits; Trumbull County, Bloomfield township, several thousand acres; many smaller deposits in Fulton, Williams, and other northern counties; not utilized.

Petroleum. Three important fields, the Lima or northwestern, the central, and the southeastern. Large production from Allen, Auglaize, Hancock, Lucas, Mercer, Ottawa, Sandusky, Seneca, Van Wert, and Wyandot counties of the northwestern field. Athens, Coshocton, Fairfield, Holmes, Knox, Lorain, Muskingum, Perry, and Vinton counties of the central field contain producing wells. Large production from wells in the southeastern field in Belmont, Carroll, Columbiana, Guernsey, Harrison, Jackson, Jefferson, Monroe, Morgan, Noble, and Washington counties. There were about 31,000 producing wells in Ohio in 1910.

Pyrite. Obtained as by-product in coal mining. Tuscarawas County, mined at Canal Dover, Midvale, New Philadelphia, Roswell, and Wainwright.

Salt (brine). Produced in Cuyahoga County, near Cleveland; Medina County, Wadsworth; Meigs County, Pomeroy; Morgan County, Durant; Summit County, Akron and Barberton; Wayne County, Rittman.

Sand (building). Dug in Allen County, near Allentown; Ashtabula County, Ashtabula; Athens County, Broadwell; Butler County, Hamilton; Clark County, Springfield; Clermont County, Miamiville; Columbiana County, East Liverpool; Coshocton County, Coshocton; Cuyahoga County, Cleveland; Darke County, Greenville; Erie County, Sandusky; Fairfield County, Lancaster; Franklin County, dredged from Scioto River, Columbus; Gallia County, dug near Gallipolis and Vinton; Hamilton County, Cincinnati; Jackson County, Coalton; Jefferson County, Brilliant; Lawrence County, Ironton; Lorain County, Brownhelm station and Lorain; Lucas County, Toledo; Mahoning County, Austintown and Youngstown; Miami County, Pleasant Hill; Montgomery County, Dayton; Muskingum County, Gilbert, Philo, Trimway, and Zanesville; Pike County, Wakefield; Portage County, Garrettsville; Richland County, near Mansfield; Sandusky County, Fremont; Scioto County, Portsmouth; Stark County, Alliance and Canton; Summit County, Akron; Tuscarawas County, Canal Dover; Washington County, Marietta; Wood County, Perrysburg.

Sand (glass). Sandstones of Silurian or Carboniferous age quarried and crushed in Erie County, at Sandusky; Hocking County, Rockbridge; Knox County, Howard; Licking County, near Toboso; Lucas County, 4 miles southwest of Sylvana; Mahoning County, Austintown; Muskingum County, Zanesville; Perry County, Chalfants; Stark County, Massillon; Summit County, Warwick; Trumbull County, 4 miles southwest of Niles; Tuscarawas County, Dundee.

Sand (molding). Dug in Ashtabula County, at Conneaut and Kingsville; Belmont County, Bellaire; Butler County, Overpeck and Hamilton; Carroll County, Sherrodsville; Columbiana County, Leetonia; Coshocton County, Layland; Cuyahoga County, Cleveland and Collinwood; Erie County, Avery, Huron, Milan, Sandusky, and Shinrock; Fairfield County, Lancaster; Gallia County, Gallipolis; Hamilton County, Delhi; Jackson County, Coalton; Jefferson County, Steubenville; Knox County, Howard; Lucas County, Toledo; Mahoning County, Austintown; Muskingum County, Dresden, Ellis, Gilbert, and Zanesville; Perry County, New Lexington; Portage County, Garrettsville; Stark County, Alliance, Canton, Crystal Springs, and Massillon; Summit County, Akron, Cuyahoga Falls, Everett, and Warwick; Tuscarawas County, Barrs Mills, Dundee, New Cumberland, and Somerdale; Washington County, Vincent.

Sandstone (building, crushed stone). Quarried in Allen County, at Allentown; Ashland County, Ashland; Belmont County, Martins Ferry; Carroll County, Sherrodsville; Cuyahoga County, Berea, South Euclid, West View, and elsewhere; Erie County, Berlin Heights; Fairfield County, Lancaster and Sugar Grove; Franklin County, Reynoldsburg; Guernsey County, Cambridge; Harrison County, Freeport; Highland County, Hillsboro; Holmes County, Glenmont; Jefferson County, Empire and Steubenville; Licking County, Newark; Lorain County, Amherst, Columbia, Grafton, and Oberlin; Mahoning County, Youngstown; Morrow County, Fulton and Iberia; Muskingum County, Zanesville and vicinity; Noble County, Sharon; Pickaway County, Circleville; Pike County, Waverly; Richland County, Mansfield; Scioto County, McDermott and Portsmouth; Stark County, Massillon; Summit County, Peninsula and Twinsburg; Trumbull County, Mineral Ridge; Washington County, Marietta; Wayne County, Wooster; Wood County, Grand Rapids.

Siderite. Occurs in Carboniferous limestones. Was formerly mined in Gallia, Jackson, Lawrence, Scioto, and Vinton counties.

OKLAHOMA.

Asphalt (rock). Extensive deposits in southern part of State, in and south of Arbuckle Mountains. Quarried for paving in Carter County, at Ardmore; Comanche County, Lawton; Murray County, at Gilsonite, 3 miles south of Sulphur, and near Dougherty. Occurs in Atoka, Bryan, Craig, Garvin, Jefferson, Johnson, Le Flore, Love, McCurtain, Ottawa, Pontotoc, and Stephens counties.

Azurite. Occurs in small quantities in Arbuckle Mountains.

Calamine. Ottawa County, mined at Quapaw and at Peoria.

Cement material (Portland). Limestones and shales suitable for cement in northeastern Oklahoma and elsewhere; utilized in Pittsburg County, at Hartshorne; Pontotoc County, Ada; and Washington County, Dewey. Shales underlying Caddo limestone in Red River region south of Arbuckle and Ouachita Mountain uplifts, suitable for Portland cement.

Cerusite. Ottawa County, occurs in Peoria mines.

Clay (brick). Dug in Beaver County, at Logan; Canadian County, 4 miles west of El Reno; Carter County, Ardmore; Choctaw County, Boswell; Craig County, Vinita; Creek County, Sapulpa; Garfield County, Enid; Grady County, Chickasha; Jefferson County, Addington and Hastings; Kay County, Blackwell; Kingfisher County, Hennessey and Kingfisher; Kiowa County, Gotebo; Le Flore County, Poteau; Logan County, Guthrie; Muskogee County, Muskogee; Nowata County, Nowata; Oklahoma County, Oklahoma City; Okmulgee County, Gaither; Pawnee County, Cleveland; Pittsburg County, McAlester; Pontotoc County, Ada; Pottawatomie County, South Beard; Rogers County, Claremore; Tulsa County, Broken Arrow, Red Fork, and near Tulsa; Washington County, Bartlesville; Woods County, Alva.

Clay (fire). Large quantities occur in coal fields: Coal County, at Lehigh and Coalgate; Latimer County, Wilburton; Pittsburg County, Blocker, Hartshorne, and McAlester.

Clay (kaolin). Reported from Cherokee County, near Tahlequah, and from Wichita Mountains.

Coal (bituminous). Carter County, Ardmore coal mined south of Ardmore, of little importance; Coal County, Lehigh district: Lehigh coal 4–7 feet, mined at Coalgate, Phillips, and Lehigh, good quality; Atoka coal 4 feet, mining limited; Craig County, good quality west of Blue Jacket, west and northwest of Welch, at Centralia and Catale; Latimer County, Wilburton district: Upper Hartshorne coal 4½ feet, mined; Lower Hartshorne 4 feet, mined in vicinity of Howe; Le Flore County, Howe-Poteau district, contains Hartshorne and McAlester coals; Lower Hartshorne mined and coked in vicinity of Howe, 4½ feet, Witteville coal around Cavanal Mountains, at Witteville, mined at Sutter, 4 feet; Panama coal mined at Panama; Muskogee County, near Boynton, Muskogee, and elsewhere; mined in considerable quantity on Dog Creek; Okmulgee County, Henryetta coal mined at Henryetta, Schulter, and Morris; Pittsburg County, McAlester district: Hartshorne coal 3–6 feet, mined at Hartshorne and elsewhere, good quality; McAlester coal along southeast side of district, southwest from Savanna, mined at Krebs and McAlester mines, 3–4½ feet; Rogers County, mined at Catoosa, Dawson coal mined at Collinsville; Tulsa

County, Henryetta coal mined at Broken Arrow; Dawson coal outcrops from near Bird Creek to southwest of Beggs, Okmulgee County, mined at Dawson, Mohawk, Tulsa, and Red Fork.

Copper (native). Small nuggets scattered through clay shale in Blaine County, near Winnview; Cimarron County, near Kenton and along valley of Cimarron River; McClain County, vicinity of Byars; Noble County, near Perry.

Galena. Ottawa County, mined with zinc ore at Miami, Peoria, Quapaw, and other districts, 25 mines in operation in 1910. Occurs in Arbuckle Mountain region.

Grahamite. Atoka County, occurs in fissure veins in Stanley shale on branch of Tenmile Creek, west side of Impson Valley; Pushmataha County, in Carboniferous rock in Jackfork Valley 10 miles west of Tuskahoma; Stephens County, in sandstone and shale near Loco.

Granite. Greer County, quarried at Granite; Johnston County, near Mill Creek, Ravia, Tishomingo, Troy, and Wapanucka; Kiowa County, Cold Springs and Roosevelt; Mayes County, reddish granite dike occurs near Spavinaw.

Gypsum. In Permian rocks; Blaine County, mined at Homestead, Watonga, and elsewhere; Caddo County, Cement; Canadian County, Okarche; Grady County, Rush Springs; Jackson County, Eldorado; Kay County, Peckham; Woodward County, Quinlan. Workable beds of gypsite occur in Blaine, Caddo, Custer, Grady, Harmon, Jackson, Stephens, and Washita counties.

Impsonite (bitumen). Pushmataha County, Moulton mine in Impson Valley and on McGee Creek.

Limestone. Jackson County, Creta and Olustee; Johnston County, large plant quarrying oolitic limestone at Bromide; Kay County, gray or nearly white, fine grained, quarried at Newkirk, Ponca, and Uncas; Nowata County, Nowata; Osage County, Pawhuska; Ottawa County, Boone limestone quarried to some extent at Wyandotte; Pawnee County, Jennings, and 1 mile west of Pawnee; Tulsa County, Skiatook, Lost City, and near Tulsa; Washington County, Bartlesville, and Dewey.

Limestone (crushed stone). Quarried in Atoka County, at Chockie; Caddo County, Cement; Comanche County, along northeast side Wichita Mountain uplift 30 miles northwest of Fort Sill, also at Richards Spur; Jackson County, Creta and Olustee; Kay County, Newkirk, Ponca, and Uncas; Murray County, Arbuckle Mountain uplift, quarried at Crusher; Nowata County, 2½ miles north of Lenapah; Osage County, Avant; Pawnee County, 1 mile east of Pawnee; Pittsburg County, Hartshorne; Tulsa County, Lost City, near Garnett, and Tulsa.

Limestone (lime). Burned in Delaware County, at Grove and at other localities, for local use; Johnston County, at Bromide and Wapanucka.

Magnetite. Comanche County, considerable deposits occur in Wichita Mountains.

Malachite. Arbuckle Mountains in small quantities; Jackson County, in sandstone near Elmer.

Manganese ore. Coal County, has been mined near Lehigh and Hunton; and Johnston County, Mill Creek.

Marble. Sequoyah County, pure white to pink marble is quarried near Marble City.

Marcasite. Ottawa County, occurs with lead and zinc ores at Miami, Peoria, and Quapaw mines.

Natural gas. Producing wells at close of 1912 numbered 870. Most productive areas of northeastern Oklahoma are: Carter County, Ardmore; Kay County, Ponca; Marshall County, Madill; Nowata County, Alluwe, Coodys Bluff, California Creek, and Delaware; Okmulgee County, Baldhill, Morris, Okmulgee; Osage County, Hominy; Pawnee County, Cleveland; Rogers County, Collinsville; Tulsa County, Tulsa; Washington County, Bartlesville, Copan, and Hogshooter

Creek. Gas occurs also in Comanche County, in small quantity at Lawton; Creek County, Cushing field; Greer County, at Granite; Kiowa County, at Gotebo; Kay County, Blackwell; Muskogee County, Muskogee; Stephens County, Duncan.

Novaculite. Atoka County, exposures near Atoka; Le Flore County, Talihina.

Petroleum. Most productive areas are in northeastern Oklahoma at or near Bartlesville, Copan, Dewey, Glenn Pool, Hamilton, Henryetta, Ramona, Red Fork, Skiatook, Tamaha, and Tulsa. Important producers at Coodys Bluff-Alluwe field; Carter County, Wheeler; Marshall County, Mahill; Osage County, Hominy; Muskogee County, Muskogee; Pawnee County, Cleveland. Small quantity found in Comanche County, at Lawton; Creek County, near Mounds; Greer County, Granite; Kiowa County, Gotebo; Mayes County, spring near Adair.

Porphyry. Suitable for fine building stone occurs near Cache, Fort Sill, Lugert, Mountain Park, Roosevelt, Snyder, Wichita Mountains, and in east and west Timbered Hills near Davis, Murray County.

Salt. Beckham County, small quantities obtained from springs near Carter; Blaine County, Ferguson and Salt Creek plain in northern part of county; Harmon County, Salton; Woods County, northeastern part.

Sand (glass). Arbuckle Mountains and in southern Oklahoma north of Red River; Cherokee County, occurs near Tahlequah.

Sand and gravel. Found in nearly every county of the State and utilized for local building.

Sandstone. Widely distributed in central and southern parts of the State, in Cleveland, Garvin, Kay, Lincoln, Logan, McClain, Noble, Oklahoma, Osage, Pawnee, Payne, Pontotoc, Pottawatomie, and other counties. Quarried mostly for local use.

Sandstone (bituminous). Carter County, quarried in Ardmore district; Johnston County, prospects 3 miles southeast of Emet; Love County, Love and Washington prospects near Marietta; Murray County, in Buckhorn and Brunswick districts; used for paving.

Smithsonite. Murray County, mined in Arbuckle Mountains near Davis.

Sphalerite (zinc blende). Murray County, mined in the Arbuckle Mountain district; Ottawa County, mined at Miami, Peoria, and Quapaw districts.

Tripoli. Ottawa County, mined near Seneca, Mo.

Volcanic ash. Occurs in beds in Beaver, Ellis, Harper, Woods, and Woodward counties.

Zinc. *See* Calamine, Smithsonite, and Sphalerite.

OREGON.

Almandite. *See* Garnet.

Argentite (silver glance). Baker County, mined in Cable Cove and Rye Valley districts.

Arsenopyrite (arsenical pyrite). Baker County, mined for gold in Elkhorn, Cable Cove, Granite, Sparta, and other districts; Grant County, Susanville district; Josephine County, Braden mine and Maid of the Mist, Grants Pass district, and Silent Friend mine.

Asbestos (chrysotile). Josephine County, reported 10 miles west of Kerby, and at other points not definitely located in the Klamath Mountains and Blue Mountains.

Azurite (blue carbonate of copper). Douglas County, occurs in Ball mine, on Cedar Springs Mountain; Josephine County, oxidized ore Queen of Bronze mine, Waldo district.

[illegible]. Lane County, occurs in Bohemia district.

Basalt. Practically every county in the State has basalt or similar rock suitable for road metal. Quarried at or near Astoria, Corvallis, Dallas, Dayton, Eugene, Forest Grove, Hillsboro, Lafayette, Lebanon, Monroe, Newberry, Portland, St. Helen, Salem, and other places.

Borax. Curry County, a calcium borate mineral (priceite) has been mined at Chetco; Harney and Lake counties, deposits of borax of the marsh type have been worked.

Bornite. Baker County, mined in Copper Butte and lower Snake River regions; Josephine County, less important ore of mines near Waldo.

Brown iron ore (limonite). Clackamas County, has been mined at Oswego; and in Columbia County, at Scappoose.

Cement material. Baker County, a large deposit of limestone on Burnt River, 3 miles from Hutchinson, forms a possible source of Portland cement material; Clackamas County, a company building a cement plant at Oswego has bought quarry locations near Roseburg; Douglas County, 5 miles east of Monitor and 4 miles southwest of Dallas, Polk County.

Cerusite (carbonate of lead). Douglas and Lane counties, secondary mineral in Bohemia district, has been mined.

Chalcedony. Jackson County, great quantity of white chalcedony occurs in the vicinity of Eaglepoint.

Chalcocite (copper glance). Baker County, mined in Copper Butte and Lower Snake River regions; Douglas County, occurs in Ball mine near Cedar Springs Mountain.

Chalcopyrite (copper pyrites). Baker County, mined in Cable, Elkhorn, Greenhorn, Sparta, Sumpter, and other districts; Grant County, Susanville district, and Copperopolis claims, Quartzburg district; Jackson County, Corporal G mine; Josephine County, Braden and Opp mines, Grants Pass district, and Queen of Bronze mine, near Waldo; Lane and Douglas counties, Bohemia district, and many other localities.

Chromite (chromic iron ore). Baker County, heavy float at Winterville placers of upper Burnt River and Bonanza districts; Douglas County, Nickel Mountain, near Riddles; Grant County, small mass in serpentine 7 miles south of Prairie, Canyon district.

Chrysocolla (silicate of copper). Josephine County, oxidized ore in Queen of Bronze mine, Waldo district.

Cinnabar. Baker County, occurs in Sumpter district; Crook County, until recently mined at Howard; Douglas County, formerly mined at two places southeast of Oakland; and recently mined at Drew; Grant County, occurs in Granite and Susanville districts; Jackson County, small prospect on Palmer Creek, near Ashland; Lane County, recently mined at Blackbutte.

Clay (brick). Clay for making brick has been dug near almost every important town in the State.

Clay (fire). Lane County, occurs 3 miles west of Eugene; Multnomah County, used at Portland.

Coal (lignite). Baker County, lignite beds occur north of Goose Creek, along Powder River; Clackamas County, near Wilhoit Springs; Clatsop and Tillamook counties, lower Nehalem field; Columbia County, upper Nehalem field; Curry County, Eckley and Shasta Costa fields; Jackson County, Rogue River Valley field, Meford and Ashland prospects; Lincoln County, Yaquina field; Morrow County, Willow Creek prospects. Impure lignite is found at many places in Willamette Valley, and in the Coast Mountains.

Coal (subbituminous). Coos County, Coos Bay field, Newport bed, 6 feet, extensively mined at Newport; Beaver Hill bed, 6 feet, mined at Beaver Hill; coal-bearing rocks of Eocene age.

Cobaltite. Grant County, occurs with chalcopyrite and gold in Quartzburg district, near Prairie City.

Colemanite. Curry County, Chetco.

Copper. *See* Azurite, Bornite, Chalcocite, Chalcopyrite, Chrysocolla, Cuprite, Malachite, Tenorite, and Tetrahedrite.

Copper (native). Curry County, occurs on lower Illinois River; Douglas County, occurs in Ball mine, near Cedar Springs Mountain.

Corundum. Josephine County, small ledge found at Grants Pass, little development; not worked at present.

Cuprite (red oxide of copper). Douglas County, occurs in Ball mine, Cedar Springs Mountain; Josephine County, oxidized ore of Queen of Bronze mine, Waldo district.

Galena. Baker County, mined in Cable Cove, Cornucopia, Elkhorn, Greenhorn, Sparta, and Sumpter districts; Grant County, Alamo, Susanville, and Quartzburg districts; and in mining districts in Cascade Mountains.

Garnet. Baker County, handsome garnets resembling rhodolite reported from near Pleasant Valley. No production during recent years. Almandine garnets found in Sulton Creek district south of Baker City.

Garnierite (nickel ore). Douglas County, occurs at Nickel Mountain, near Riddles.

Genthite (nickel ore). Douglas County, occurs at Nickel Mountain, near Riddles.

Gold (lode). Baker County, 6 producing mines at Baker City and Virtue; Bonanza district, 1 mine at Geiser; Cornucopia district, 4 deep mines operating; Cracker Creek district, 6 deep mines at Bourne and Sumpter; Mormon Basin, 4 deep mines near Rye Valley; Clackamas County, Chena Creek district; Douglas County, deep mines at Booth, Glendale, and Nugget; Grant County, in Alamo, Canyon, Crane Creek, Granite, Quartzburg, and Susanville districts; Jackson County, deep mines in Applegate, Ashland, Draper, Gold Hill, Jacksonville, and Pleasant Valley districts; Josephine County, 10 deep mines in Althouse, Davidson, Galice, Grave Creek, and Wolf Creek districts; Lane County, 4 deep mines in Blue River and Bohemia districts; Malheur County, 2 deep mines at Rye Valley and Malheur; Marion County, near Detroit, in Santiam district; Wheeler County, 1 small mine in Spanish Gulch district.

Gold (placer). Baker County, small amount sluicing in Baker, Buck Gulch, and Cracker Creek districts; Mormon Basin, Deep Creek, and Rye Valley hydraulics; Bridgeport district, 3 hydraulic, 2 drift, and 2 sluicing mines; also in Sanger, Stice, and Weatherby districts; Coos County, Eden, Myrtle Point, and Randolph districts; Crook County, in black sand at Howard; Curry County, at Chetco, Corbin, Selma, Eckley, Marial, Ophir, and Port Orford; Douglas County, hydraulics at Booth and Glendale; sluicing at Dillard; Grant County, hydraulic at Austin, Poker Flat district, and 2 miles from Beach Creek Post Office; 4 hydraulics at Canyon City, 1 at Galena; dredge at Granite; hydraulic at Saw Mill Gulch, Quartzburg district; Harney County, 2 small sluicing properties at Harney City; Jackson County, 3 dredges at Gold Hill and Woodville, Foots Creek district; 9 hydraulic mines at Applegate, Draper, Rockpoint, Jacksonville, and Weimer; Josephine County, 26 hydraulic mines, 2 dredges, 1 drift, and 7 sluicing mines, in following districts: Althouse, Galice, Grave Creek, Josephine, Picket Creek, Williams, Winona, and Wolf Creek; Lincoln County, Yaquina Bay and Toledo, in black sand; Malheur County, Quartz Gulch and Mormon Basin, hydraulic and a few sluicing mines; Multnomah County, Latourelle and Portland, found sparingly in black sand; Wheeler County, 2 hydraulic mines in Spanish Gulch district; placer gold found in many other places in small quantity.

Granite. Quarried in Baker County, at Haines and Pleasant Valley; Jackson County, Medford; Josephine County, Grants Pass; Union County, Elgin and La Grande.

Gypsum. White and crystalline gypsum occurs on east border of State on ridge between Burnt River and Snake River; Baker County, mined and milled at Gypsum near Huntington; Crook County, deposit near Bend, undeveloped.

Hematite (red iron ore). Douglas and Lane counties, intermingled with sulphides in Bohemia district; mined for gold.

Hematite (specularite). Baker County, occurs in argillite on Burnt River divide near Sumpter.

Hessite. Baker County, occurs in Sumpter district.

Infusorial earth. Klamath County, found near Linkville; Wasco County, was mined at Mosier; occurs in Baker, Lane, Malheur, Union, and Wheeler counties.

Josephinite (nickel ore). Josephine County, occurs in placers of Josephine Creek.

Limestone (flux). Baker County, Lime; Jackson County, near Rock Point on Rogue River.

Limestone (lime). Baker County, burned near Huntington, Durkee, and Lime; Douglas County, Roseburg; Grant County, 4 miles east of Canyon City; Jackson County, on Rogue River near Rock Point, and on Kane Creek, south of Gold Hill; Wallowa County, at Lostine City.

Limonite. *See* Brown iron ore.

Malachite (green carbonate of copper). Baker County, considerable quantity at Copper Queen mine, Copper Butte district; Douglas County, small quantity in Ball mine; Grant County, Copperopolis claims, Quartzburg district; Josephine County, oxidized ore in Queen of Bronze mine, Waldo district.

Marble. Douglas County, has been quarried 9 miles southeast of Roseburg.

Marcasite. Baker County, Sumpter district; Grant County, in quartz-gold veins in Granite and Quartzburg districts.

Mineral paint. Iron ore for making paint has been dug in Columbia County, at Scappoose; Lane County, near Creswell.

Mirabilite (glauber salt). Lake County, in ponds and lakes.

Monazite. In black sands in Clatsop County, at Astoria, Warrenton, and elsewhere; Coos County, Randolph district; Curry County, Gold Beach; Josephine County, Holland, Sucker Creek, and Placer; Linn County, Foster; Multnomah County, Latourelle; Polk County, Fall City; Umatilla County, Weston; Wallowa County, Wallowa; Wasco County, Hood River; Wheeler County, Antone.

Natron. In Lake County, in lakes and ponds.

Natural gas. Malheur County, occurs in several wells near Vale and Ontario, not commercially developed.

Nickel. *See* Garnierite, Genthite, and Josephinite.

Niter (saltpeter). Lane County, ledge near Mount June; also in marsh deposits of southeastern Oregon.

Opal. Baker County, abundant in tuff, a few miles below Durkee, has been mined.

Platinum. Principal production from beach sands in Coos County, near Bullards; and Curry County, near Port Orford. Occurs in black sands in Baker County, at Durkee; Coos County, Randolph district; Curry County, Ophir; Douglas County, Drain, Glendale, and Riddles; Josephine County, Galice, Waldo, Greenback, and elsewhere; Linn County, Foster; Union County, La Grande; Wheeler County, Antone.

Pyrargyrite. Baker County, mined in Elkhorn, Sumpter, and Rye Valley districts; Grant County, Granite district.

Pyrite. Found in nearly all mining districts of Baker, Grant, and Union counties; mined for gold, Jackson County, Braden, Opp, and Tin Pan mines, Grants Pass district; Josephine County, Queen of Bronze mine near Waldo, Greenback, Baby, Silent Friend, and Orofino mines; Lane and Douglas counties, has been mined in Bohemia district. Occurs in all districts of the Cascade Mountains north of Bohemia.

Pyrolusite. Baker County, occurs in Sumpter district.

Pyrrhotite. Baker County, carries gold in Virtue district; Jackson County, Braden and Jewet mines, Grants Pass district, and Corporal G mine; Josephine County, Queen of Bronze mine near Waldo.

Quicksilver. *See* Cinnabar.

Salt. Reported abundant in numerous marshes and lakes in Lake County and elsewhere.

Sand and gravel. Dug at following places: Benton County, Corvallis; Klamath County, Klamath Falls; Lane County, Eugene; Lime County, Albany; Marion County, Salem; Multnomah County, Portland and St. Johns.

Sandstone. Has been quarried locally in Benton, Clackamas, Coos, Curry, Douglas, Lane, Lincoln, Polk, Union, Washington, and Yamhill counties. The use of cement has led to the suspension of operations in many places. The most important quarries are at Oakland, Douglas County, and at Pioneer, Lincoln County.

Silver. Baker County, predominant metal produced at Iron Dike (Homestead) district. Occurs in most lode gold districts. The principal producers of lode and placer silver are Baker, Grant, Jackson, Josephine, and Malheur counties. *See also* Argentite and Pyrargyrite.

Sphalerite (zinc blende). Baker County, Cable Cove, Elkhorn, Greenhorn, Sparta and Sumpter districts; Grant County, Alamo, Quartsburg and Susanville districts; Jackson County, mined for gold in Corporal G mine; Lane and Douglas counties, occurs in Bohemia district.

Stibnite. Baker County, occurs in Sumpter and Virtue districts; Jackson County, in fractures of greenstone 2 miles north of Watkins; Lane and Douglas counties, in Bohemia district.

Sylvanite. Baker County, occurs in quartz vein at Bryan mine, Cornucopia district.

Tenorite. Josephine County, oxidized ore in Queen of Bronze mine, Waldo district.

Tetrahedrite. Baker County, Cable Cove, Greenhorn, and Virtue districts; Grant County, Susanville district, small quantity in Badger mine.

Tetrahedrite (mercurial, schwatzite). Baker County, occurs in Sumpter district.

Zinc. *See* Sphalerite.

Zircon. Baker County, found in black sands in upper Burnt River and Bonanza placer mines.

PENNSYLVANIA.

Amethyst. Bedford County, reported at East Bedford; Chester County, Pocopson, Sadsbury, and East Bradford townships; Delaware County, 1½ miles northeast of Media, at other localities in Upper Providence, Middletown, and Astor townships; Huntingdon County, Birmingham; Philadelphia County, forty-second ward; occasionally stones suitable for gems.

Anthracite. *See* Coal.

Azurite (blue carbonate of copper). Berks County, Fritz Island, near Reading, sparingly with copper ores and magnetic iron ore; Lebanon County, Cornwall, with chalcopyrite and malachite in magnetic iron ore; Montgomery County; has been mined at Perkiomen mine, near Audubon (formerly Shannonville), Upper Salford Township, near Sumneytown, Eaton mine, Lower Providence Township.

Barite (heavy spar). Butler County, occurs west of New Hope; in several old mine holes; Chester County, at Phoenixville mines and found in small quantity in old Jug Hollow mine, Schuylkill Township; Franklin County, mined to a small extent near Chambersburg and Waynesboro; Fulton County, formerly mined at Fort Littleton; Montgomery County, at the Perkiomen copper mines. Barite is not mined on a commercial scale in Pennsylvania at present.

Beryl. Delaware County, Deshong's quarry, Chester; Avondale quarry, near Media, Concord, Linwood; occasionally found.

Bluestone. *See* Sandstone.

Bromine. Allegheny County, concentrated from brine at Pittsburgh.

Brown iron ore (limonite). Extensively developed in the Great Valley from Delaware River to the Maryland line. Many scattered ore banks have been worked out in Berks, Cumberland, Dauphin, Franklin, and Lebanon counties; occurs in Chester and Montgomery counties in a narrow belt crossing the Schuylkill at Spring Mill; Bedford, Huntingdon, and Mifflin counties, occurs in Juniata region; Blair County, in Yellow Creek district; Lancaster County, in the Chestnut Hill and other ore banks. Middle Pennsylvania, in Kishacoquillas, Nittany, Morrisons Cove, and Sinking Canoe valleys; Juniata and Perry counties on the affluents of the Juniata; York County, irregular masses scattered through clay near Dillsburg, mined at Heck mine. Western Pennsylvania: Armstrong County, formerly worked in West Franklin Township; also occurs in Beaver, Butler, Clarion, Center, Clearfield, Jefferson, Indiana, and Lawrence counties. *See also* Mineral paint.

Calamine (zinc silicate). Columbia County, Espy; Lancaster County, Lancaster; Lehigh County, Friedensville, Saucon Valley, with blende in limestone; not mined.

Carnotite. Carbon County, on Mount Pisgah, three-fourths of a mile north of Mauch Chunk.

Cement material. Pennsylvania leads all the States in production of Portland cement, output in 1911 being 26,864,679 barrels. There are 20 or more plants in the Lehigh district and single plants at York, Pittsburgh, Newcastle, and Wampum. Limestone and shale suitable for cement making are abundant throughout the State. Rock is quarried for cement in Berks County, at Evansville and Molltown; Lawrence County, at Newcastle and Wampum; Lehigh County, Allentown, Cementon, Coplay, and Egypt; Northampton County, Bath, Martins Creek, Nazareth, Northampton, Siegfried, and Stockertown. Blast furnace slag and limestone are used at Pittsburgh, Allegheny County, for Portland cement. Clay dug at Mount Holly Springs, Cumberland County, is used for white cement.

Cerusite (lead carbonate). Bradford County, in Carpenter mine, near New Albany; Chester County, in small quantities at Phoenixville lead mines, Schuylkill Township; Lancaster County, Lancaster; Montgomery County, Ecton iron and copper mines, Lower Providence Township.

Chalcocite (copper glance). Chester County, in small quantity at Phoenixville lead mines, Schuylkill Township, French Creek mines, Warwick Township; Lancaster County, Woods mine, Little Britain Township; Montgomery County, Perkiomen copper mines, Lower Providence Township.

Chalcopyrite (copper pyrites). Berks County, formerly mined at Jones's mine, and at Fritz Island mine near Reading; Chester County, Wheatley lead mine, Phoenixville, French Creek iron and copper mines, Warwick Township. Found only in small quantity in Delaware County, Arondale quarries; Lancaster County, Gap nickel mine; Lebanon County, occurs with other copper ores and is mined with magnetite at Cornwall, elsewhere unimportant as an ore; Montgomery County, near Lafayette Hill soapstone quarry; Philadelphia County, in gneiss at Frankford and on Wissahickon Creek.

Chromite (chromic iron ore). Delaware County, occurs in serpentine near Ox Run in Newton Township, near Palmers Mill, Marple Township, and elsewhere in the serpentine. Lancaster County, occurs in serpentine at Woods mine on Octoraro Creek and elsewhere in the "State line" serpentine, Lancaster and Chester counties.

Clay (brick). Brick clay occurs in most counties of the State and is dug in at least 44 of them. The production of common brick in 1911 was valued at nearly $5,000,000.

Clay (fire). Mined, often in connection with coal, in Allegheny, Armstrong, Beaver, Berks, Cambria, Carbon, Clarion, Center, Clearfield, Clinton, Cumberland, Elk, Fayette, Indiana, Jefferson, Juniata, Lackawanna, Lawrence, Lehigh, Luzerne, Lycoming, McKean, Montgomery, Perry, Snyder, Somerset, Union, and Westmoreland counties.

Clay (kaolin). Pits in Berks County, at Blandon and Mertztown; Chester County, at East Nottingham, Kennett, and New Garden; Cumberland County, Mount Holly Springs, Toland; Huntingdon County, Birmingham Township; Franklin County, Concord Township; Montgomery County, Plymouth Township.

Coal (anthracite). Anthracite region covers parts of Carbon, Columbia, Dauphin, Lackawanna, Luzerne, Northumberland, Schuylkill, Sullivan, Susquehanna, Wayne, and Wyoming (not mined) counties. Of these, the most important are Carbon, Lackawanna, Luzerne, Northumberland, and Schuylkill. Total production in 1911 was 80,771,488 long tons.

Coal (bituminous). Coal-bearing rocks cover practically the whole of Allegheny, Armstrong, Blair, Butler, Beaver, Cambria, Clearfield, Cumberland, Greene, Indiana, Jefferson, Lawrence, Washington, and Westmoreland counties; the greater portions of Clarion, Elk, Fayette, Mercer, and Somerset counties; and parts of Bedford, Blair, Bradford, Cameron, Center, Clinton, Crawford (not mined), Forest (not mined), Fulton (not mined), Huntingdon, Lycoming, McKean (not mined), Tioga, and Venango (not mined) counties. Chief producers are Allegheny, Butler, Cambria, Clearfield, Fayette, Indiana, Jefferson, Somerset, Washington, and Westmoreland counties. Total production in 1911 was 144,754,163 short tons.

Copper minerals. There are no valuable deposits of copper ore in eastern Pennsylvania; localities listed are well-known sources of museum specimens. *See also* Azurite, Chalcocite, Chalcopyrite, Cuprite, and Malachite.

Copper (native). Formerly mined in Bucks County, near Buckmanville, and Cumberland County, at South Mountain. Also found in small quantity in Adams County, Millerstown; Chester County, French Creek mines, and Phoenixville lead mines; Lebanon County, at Cornwall; Lancaster County, Jones's iron mine; Montgomery County, Perkiomen copper mine.

Corundum. With serpentine belt in Bucks, Chester, Delaware, Lancaster, and Montgomery counties; has been mined northeast of Unionville, Chester County. Not produced at present time in Pennsylvania.

Cuprite (red oxide of copper). Adams County, copper mines near Maryland line; Lebanon County, Cornwall; Montgomery County, sparingly at Perkiomen mine; Northampton County, Chestnut Hill near Easton.

Feldspar (orthoclase, microcline). Chester County, mined at Chatham, Toughkenanon, and Pomeroy; has been mined at Baker Station, Avondale, Embreeville, and Unionville; Delaware County, mined at Brandywine Summit, has been mined at Chester Heights, Glen Mills, and between Chelsea and Boothwyn in Middletown.

Feldspar (albite). Chester County, mined in town of West Nottingham, Pa., near Sylmar Station, Md.

Flagstone. *See* Sandstone.

Fluorspar. Chester County, Wheatley mine, Schuylkill Township; Columbia County, Newlin; Franklin County, Lancaster Station; Lebanon County, Cornwall; Monroe County, Delaware Water Gap; Philadelphia County, Frankford and Falls of Schuylkill.

Galena. Blair County, Sinking Valley, accompanying zinc ores; Bucks County, New Britain; Chester County, Phoenixville lead mines; Lancaster County, Pequea mine, argentiferous; Schuylkill County, near Pottsville; Montgomery County, Perkiomen mines.

Ganister. Extends through mountain region of central Pennsylvania; mined for silica brick in Bedford County, at Pattonsville; Blair County, McKee Gap and Point View; Huntingdon County, Water Street Gap.

Garnet. Delaware County, formerly mined 1 mile southwest of Chelsea, abrasive. Found in small crystals in the Wissahickon mica gneiss of Chester, Delaware, and Montgomery counties along the serpentine contact.

Gold. Chester County, Phoenixville lead mines, in copper pyrites. Montgomery County, Franconia and Douglas townships, sparingly in quartz and pyrite.

Granite (including gneiss). Berks County, quarried at Seisholtzville; Bucks County, Rist Hill and Trevose; Chester County, St. Peters, West Chester, and West Grove; Delaware County, Cardington, Chester, Morton, Clifton Heights, Leiperville, and elsewhere; Montgomery County, Haverford, Ogontz, Spring Mill, and Wynnewood; Philadelphia County, Upper Dartz, Holmesburg, Philadelphia, Chestnut Hill, Overbrook, and Olney.

Graphite. Berks County, has been mined at Boyertown and at Mertztown; Chester County, mined at Byers (Uwchland Post Office) Coventryville and Chester Springs; has been mined at Anselma, Charlestown, and Kimberton.

Greenockite. Lehigh County, found at Friedensville.

Halite. *See* Salt.

Hematite (fossil iron ore, dyestone ore). In the Clinton formation, from Bloomburg, Columbia County, and Danville, Montour County, traceable through Center, Fulton, Juniata, Mifflin, Northumberland, Perry, Snyder, Union, and Huntingdon counties of middle Pennsylvania, and thence through Bedford County to the State line on the south. Fossil ores were also mined in the north, in Bradford, Lycoming, and Tioga counties.

Hematite (specular iron ore). Armstrong County, was formerly mined along outcrop for many miles in vicinity of Kittanning; Bucks County, occurs near Durham; Chester County, with magnetite at Warwick; Franklin County, micaceous Clinton ore in Catholic Valley, southeast ridge of South Mountain, near Chambersburg; Lebanon County, mined with magnetite at Cornwall; York County, near Hanover, at Dillsburg and Wellsville, the Codorus region.

Kaolin. *See* Clay.

Lead. *See* Cerusite, Galena, and Wulfenite.

Limestone. Extensively quarried over a large part of the State, for building stone, crushed stone, and flux.

Limonite. *See* Brown iron ore.

Magnetite. Berks County, formerly mined at Boyertown, Fritz Island, near Jacksonwald, near Joanna Station, near Reading and Wheatfield; Chester County, formerly mined at Falls of French Creek, and at Warwick; Dauphin County, formerly mined at Hummelstown; Lebanon County, mined at Cornwall, and formerly mined near Mount Pleasant; York County, mined at Dillsburg.

Malachite. Adams County, in copper mines near Maryland line; Berks County, Jones's mine near Morgantown and Fritz mine near Reading; Bradford County, formerly mined with other copper ores at Carpenter mines near New Albany; Chester County, found in small quantity at the French Creek and Phoenixville mines; Lebanon County, Cornwall mines; Montgomery County, Perkiomen mine; Perry County, Millerstown.

Manganese ore. In Berks, Blair, Center, Huntingdon, and Northampton counties; Cumberland County at Mount Holly Springs; Dauphin County at several places on Broad Mountain; Lehigh County, in small quantities in iron-ore deposits at Ironton; has been mined to slight extent in connection with iron ores.

Marble. Chester County, quarried at Avondale, Bakers Station, and Westgrove; Montgomery County, at King of Prussia and other localities.

Melaconite. Bradford County, formerly mined with other copper ores at Carpenter mine, near New Albany; Chester County, found in small quantity at Phoenixville lead mines; Montgomery County, Perkiomen mines.

Millerite (capillary pyrites, nickel sulphide). Lancaster County, small quantity in Gap nickel mine, with copper-bearing pyrrhotite, copper pyrites, etc.

Millstones. Lancaster County, East Earl and Lincoln.

Mineral paint. Berks County, mined at Blandon, Fleetwood, Hancock, Reading, and Topton; Cambria County, at Johnstown; Carbon County, belt 7 miles southeast of Mauch Chunk extends in southwest direction 20 miles, mined at Hazard and Millport; Lawrence County, Pulaski; Lehigh County, mined at Breinigsville and Alburtis; Luzerne County, has been mined at Moosehead, 5 miles north of Whitehaven; Northampton County, has been mined at Camels Hump, 3½ miles northeast of Bethlehem, and near Easton. *See also* Shale.

Moonstone. Chester and Delaware counties, found in several localities.

Natural gas. Chiefly from Elk, Greene, McKean, Warren, and Washington counties, and to a less extent from Armstrong, Beaver, Butler, Fayette, Indiana, Lawrence, Venango, and Westmoreland counties. More than 10,000 producing wells at close of 1911.

Ocher. *See* Mineral paint.

Petroleum. Produced in Allegheny, Armstrong, Beaver, Bradford, Butler, Clarion, Crawford, Elk, Fayette, Forest, Greene, Lawrence, McKean, Mercer, Tioga, Venango, Warren, and Washington counties. There were 52,545 producing wells at the close of 1911.

Pyrite. Lancaster County, has been mined at Gap mine, nickeliferous; Lebanon County, Cornwall, cupriferous and cobaltiferous; York County, with magnetite in James's iron mine, Dillsburg. The only commercial output of pyrite reported during the last few years is the small quantity obtained in connection with the mining of bituminous coal in Mercer County.

Pyrolusite (black oxide of manganese). Montgomery County, Edge Hill, and near Spring Mill; Lehigh County, commonly associated with limonite, especially in Saucona Township.

Pyrrhotite (magnetic pyrites). Berks County, in Alsace Township, near Reading; Lancaster County, at Gap mine, nickeliferous; in small quantities at several other localities.

Quartz. Adams County, mined at Bendersville; Chester County, mined at Cornog Station and on North Valley Hills, for pottery and abrasives; Monroe County, quartz suitable for gems found at Stroudsburg.

Salt (brine). Allegheny County, produced in Pittsburgh; Armstrong County, has been made at Bayard salt works, Long Run; Beaver County, New Brighton, Bellowsville, and Industry; Bradford County, oil district; Fayette County, on Youghiogheny River; and Indiana County, at Saltsburg. Bromine and calcium chloride are also obtained from the natural brine.

Sand (building). Local deposits utilized in majority of the counties.

Sand (glass). Dug in Clearfield County, at Falls Creek; Elk County, Daguscahonda; Fayette County, at Dunbar, and along Monongahela River near Belle Vernon; Huntingdon County, Mapleton; Mifflin County, Vineyard; Venango County, Kennerdell and Rockmere Station near Oil City.

Sand (molding). Dug in Allegheny County, at Pittsburgh; Beaver County, Koppel; Berks County, Berne and Hamburg; Blair County, Hollidaysburg; Bucks

County, Tullytown; Butler County, Cabot; Carbon County, Ashfield and Bowmanstown; Clearfield County, Falls Creek; Columbia County, Catawissa, Mifflinville, and Rupert; Dauphin County, Harrisburg; Elk County, Ridgway; Erie County, Erie and Fairview; Fayette County, Dunbar, West Masontown, Perryopolis, and Republic; Franklin County, Waynesboro; Huntingdon County, Mapleton Depot and Mill Creek; Lancaster County, Marietta, Beartown, and elsewhere; Lawrence County, Moravia and Newcastle; Lehigh County, Cementon; Lycoming County, Linden and Nisbet; Mercer County, Carlton; Mifflin County, Burnham and Lewistown; Montgomery County, Edge Hill and William Penn; Northampton County, South Bethlehem and Freemansburg; Northumberland County, Milton and Riverside; Philadelphia County, Philadelphia; Perry County, Newport; Somerset County, Rowena; Sullivan County, Lopez; Venango County, Utica and South Oil City; Westmoreland County, New Stanton; York County, near Weigelstown.

Sandstone. Quarried at various localities in majority of the counties of the State.

Sandstone (bluestone). Chiefly quarried in the northeastern part of the State: Allegheny County, Pittsburgh; Bradford County, Sugar Run, Towanda, and Wyalusing; Fayette County, Upper Middletown, Waltersburg; Luzerne County, Hunlock Creek; Lycoming County, Jersey Mills, Trout Run, and Waterville; McKean County, Port Allegheny; Mercer County, Greenville; Pike County, Lackawaxen, Pond Eddy, Millrift, Kimble, and elsewhere; Potter County, Burtville; Susquehanna County, Dimock, Hallstead, Lanesboro, and elsewhere; Venango County, Franklin; Westmoreland County, Hillside, Ligonier, and Penns Station; Wyoming County, Blackwalnut and Laceyville; York County, Hanover.

Sandstone (brownstone). Quarried in Berks County, at Birdsboro and Mohrsville; Bucks County, Grenoble Station, Lumberville, Neshaminy, Newton, and Yardley; Chester County, Phoenixville and Valley Forge; Dauphin County, Hummelstown; Lebanon County, Mount Gretna and Schaefferstown; Mercer County, near Jackson Center; Montgomery County, Morristown, Port Kennedy, and Fort Washington. Formerly quarried in Dauphin County, at Middletown, and York County, at Goldsboro (Etters).

Sandstone (flagstone). Bradford County, New Era; Monroe County; Pike County, near Delaware River and Lackawaxen Creek, numerous quarries in grits and sandstones in Shohola and Lackawaxen; Schuylkill County, Auburn; Sullivan County, Dushore; and Wyoming County, Nicholson. In northwestern and western counties, flagstone quarried for local use in many places.

Serpentine. Berks County, precious serpentine on Fritz Island, near Reading; Chester County, serpentine occurs in West Nottingham and West Town townships, and precious serpentine at Low's mine, Fulton Township; Delaware County, near Media, in Radnor Township; Northampton County, verdolite, an ornamental stone essentially serpentine, is quarried at Easton. Serpentine occurs but is not worked in Lancaster, Lebanon, Montgomery, and York counties.

Shale. *Black shale.*—Berks County, mined for pigment at Fritz Station; Clinton County, Rauchtown; Lycoming County, Muncy; Northampton County, Nazareth, formerly mined; Schuylkill County, Pottsville.

Yellow shale.—Berks County, occurs at Shoemakersville; Carbon County, formerly mined at Lehigh Gap and Slatington; Luzerne County, mined for pigment at Moosehead station.

Red shale.—Berks County, mined for pigment at Albany, formerly mined at Lenhartsville; Lawrence County, mined at Pulaski; Luzerne County, at Hudsondale; Tioga County, at East Charlestown; Westmoreland County, mined for pigment at Greenwald; Wyoming County, formerly mined at Factoryville.

Siderite (iron carbonate). An important ore formerly mined in eastern Pennsylvania with limonite. Now mined only in Carbon County, at Lehigh Gap, for paint. Formerly mined in Bedford, Clearfield, Cambria, Fayette, Fulton, Huntingdon, Mifflin, and Somerset counties; in the Lackawanna Valley and at Scranton; in Lycoming County at Ralston.

Siderite (black band ore). Black band ores also occur throughout the northern coal field, but are not persistent, though occurring at the same horizon; not now mined.

Sienna. Berks County, 1 mile east of Reading.

Slate. Quarried in the following localities: Lehigh County, Slatington; Northampton County, Bangor, Berlinsville, Chapman, Danielsville, Heimbach, and Pen Argyl; York County, Delta and Peach Bottom.

Smithsonite (zinc carbonate). Blair County, Sinking Valley; Lancaster County, Lancaster zinc mines; Lehigh County, Friedensville zinc mines, with calamine and blende. Not worked alone as an ore.

Sphalerite (zinc blende). Blair County, Sinking Valley, with galena and smithsonite; Bucks County, New Britain, with galena; Chester County, Phoenixville mines, with lead ores and in considerable quantity; Columbia County, Espy, in limestone; Lancaster County, Lancaster zinc mines and Pequea mine, with galena; Lehigh County, Friedensville zinc mines, Saucona Valley, with blende and smithsonite in limestone; Montgomery County, Perkiomen and Eaton mines near Audubon. No longer worked.

Talc. Chester County, was formerly obtained in West Goshen Township, near Unionville; Montgomery County, formerly quarried at Gladwyne, and Lafayette Hill; Northampton County, quarried at Easton.

Trap rock (Triassic diabase and pre-Cambrian gabbro). Quarried in Adams County, at Gettysburg; Berks County, Birdsboro; Bucks County, Point Pleasant and Rushland; Dauphin County, Rockville (Fort Hunter); Delaware County, Glen Mills, Locksley, Radnor, and Wayne; Luzerne County, Wapwallopen; Montgomery County, Green Lane, Pottstown, and Sumneytown; Perry County, Marysville.

Umber. Berks County, Bethel; Bucks County, Doylestown; Northampton County, Quaker Hill.

Wad (bog manganese). Berks, Lehigh, Northampton, and other counties with limonite.

Wavellite. Chester County, has been found; Cumberland County, formerly mined in vicinity of Moores Mill, 4 miles west of Mount Holly Springs, and used in the manufacture of phosphorus.

Wulfenite (molybdate of lead). Chester County, Wheatley lead mines, Phoenixville; Lancaster County, Pequea mines; Montgomery County, Perkiomen and Eaton mines, near Audubon.

Zinc. *See* Calamine, Smithsonite, and Sphalerite.

RHODE ISLAND.

Agate. Providence County, occurs with chalcedony and quartz in southern portion of Diamond Hill, town of Cumberland.

Anthracite. *See* Coal.

Brown iron ore (limonite, brown hematite). Providence County, was mined at Cranston during Revolutionary times.

Brown iron ore (bog iron ore). Providence County, occurs 3 miles west of Foster Center, near State line.

Chalcopyrite. Providence County, was prospected extensively probably over 100 years ago near Sneech Pond, town of Cumberland.

Clay (brick). Bristol County, dug at Barrington and Nyatt; Providence County, old clay pits at Pawtuxet, town of Cranston, and west of Diamond Hill, town of Cumberland.

Clay (pottery). Newport County, reported on Block Island and at Newport Neck.

Coal (anthracite). Newport County, has been mined intermittently for a century at Portsmouth; three beds 1 to 3 feet thick, high percentage of ash, made impure by pyrite and quartz veinlets; hard to ignite, holds fire poorly; adapted for smelting but not successful steaming or domestic fuel. Has been mined also at Bristol, at Portsmouth Station on western side of northern part of Aquidneck Island, Cranston, and Pawtucket. Attempts have been made to briquet coal produced at Portsmouth in recent years. Was once mined at Cranston for graphite where most of this coal is graphitic.

Dolomite. Providence County, this "hard jointer" limerock was quarried from several small occurrences and burnt for lime in towns of Lincoln, Johnston, North Providence, and Providence.

Flagstone. Sandstone suitable for flagging has been quarried at Pawtucket.

Galena. Washington County, was once mined at Tower Hill, in Kingston, for molding dust for iron founders; 30 tons taken.

Granite. Newport County, has been quarried at Newport; Providence County, has been quarried at Ashton, near Providence, and Pascoag; Washington County, large quarries at Bradford and Westerly, for building and ornamental stone and paving blocks.

Graphite. Newport County, 200 tons mined about 4 miles south of Tiverton as basis for paint; Providence County, largest mine at Fenner Ledge, Cranston, near Providence, has produced several thousand tons; has been mined at Bridgeton, Pawtucket, and Valley Falls; several hundred feet of underground workings at latter place now full of water; Washington County, has been mined at Saunderstown.

Hematite. Providence County, occurs at Diamond Hill and Cranston.

Limestone. Providence County, is quarried and burned for lime at Limerock, town of Lincoln, and formerly near Centerdale.

Limonite. *See* Brown iron ore.

Magnetite. Providence County, occurs with copper ore in veins in ancient mine at Sneech Pond and in Iron Mine Hill, 2½ miles east of Woonsocket, as a prominent constituent of the gabbroid rock; beach sands on south shores.

Manganese ore. Providence County, resembles knebelite; occurs in bed 40 feet thick, near Sneech Pond, town of Cumberland.

Molybdenite. Providence County, occurs in manganese ore near Sneech Pond, town of Cumberland.

Peat. In fresh and salt swamps in many parts of State, including Block Island, where it was much used for fuel.

Quartz. Providence County, constitutes southern portion of Diamond Hill, town of Cumberland. Mainly milky quartz, but banded frequently; used for road material and for concreting.

Rhodonite. Providence County, occurs at Pawtucket and Sneech Pond.

Road metal. Glacial bowlders of quartzite conglomerate, quartzite, green schist, diorite, are most commonly hauled to crusher, or quarried direct from conglomerate occurrences. Scattered trap dikes from 1 foot to 10 feet wide along east slope of hills west of Smithfield station (not used), Snake Den, Woonsocket, north of Moosup Valley, Iron Mine Hill, Ironstone Reservoir. *See also* Quartz.

Sand and gravel. Large quantities utilized in concrete work in cities; abundant throughout State.

[illegible]. For building (dimension stone), several quarries near Providence.

Serpentine. Newport County, occurs at Newport; Providence County, occurs at Smithfield, Johnston, and North Providence.

Talc. Providence County, quarried and ground at Manville.

Wad (bog manganese). Providence County, occurs at Sneech Pond, town of Cumberland.

Whetstones. Providence County, have been made in large quantities from mica slate at Smithfield and Woonsocket, and from quartz-mica schist in Smithfield.

SOUTH CAROLINA.

Amethyst. Fine crystals occur in Abbeville County, near Lowndesville; Anderson County, near Moffettsville.

Asbestos. Narrow veins occur in Anderson County, 8 miles southwest of Anderson; Cherokee, Newberry, and Pickens counties; Oconee County, near Seneca; Spartanburg County, near Spartanburg, not worked.

Aquamarine. Anderson County. *See also* Beryl.

Beryl. Anderson County, occasional clear crystals from McConnel place, 2 miles west of Anderson; occurs at numerous points along the Anderson-Spartanburg zone; cut for gems.

Barite. Cherokee County, mined at Kings Creek.

Cassiterite (tin ore). Cherokee County, occurs in pegmatite veins near Gaffney; Chesterfield County, Brewer mine. Many attempts have been made to mine the deposits of Cherokee County and neighboring counties in North Carolina.

Cement material (Portland). Many beds of marble in the western part of the State seem to be suitable for cement, but fuel, local market, and cheap transportation are lacking. Soft limestones, so-called "marls," abundant in Coastal Plain, might make satisfactory cement material.

Chalcopyrite (copper pyrites). Was formerly mined in Abbeville County, near Calhoun Falls; Saluda County, in Culbreath mine, 6 miles northeast of Saluda Courthouse; York County, Big Wilson mine near Yorkville, and Mary mine 4 miles northeast of Yorkville.

Clay (brick). Widely distributed. Dug in Abbeville County, at Abbeville; Aiken County, Hamburg and North Augusta; Anderson County, on Oconee side of Eighteen Mile Creek, near Pendleton; Beaufort County, Hardesville; Cherokee County, Gaffney; Chester County, Leeds; Chesterfield County, Cheraw and Chesterfield; Darlington County, Society Hill; Dorchester County, Badham and Summerville; Florence County, Florence; Greenville County, Greenville, Woods Crossing, and Greer; Greenwood County, Greenwood and Wareville; Horry County, Conway; Kershaw County, Camden; Lancaster County, Van Wyck; Laurens County, Laurens; Lee County, Bishopville; Lexington County, Casey; Marion County, Dillon and Mullins; Newberry County, near Newberry; Oconee County, Richland and near Westminster; Orangeburg County, Orangeburg; Pickens County, Pickens; Richland County, 1 mile west and 4 miles north of Columbia; Saluda County, Saluda; Spartanburg County, Cedar Spring and Spartanburg; Sumter County, Sumter; Williamsburg County, Greelyville and Kingstree; York County, Grallay station, Rock Hill, and Yorkville.

Clay (fire). Dug in Richland County, at Killian and near Columbia.

Clay (pottery and paper sizing). Common in Upper Cretaceous deposits; Aiken County, mined near Bath, Beach Island, Graniteville, and Langley; also in Kershaw, Lexington, and Richland counties. White Potomac clay dug in Aiken County, at Aiken and near Bath; Richland County, at Columbia.

Coal. *See* Lignite.

Cobalt. Aiken County, cobalt-bearing manganese exposed in placer bed at base of alluvial deposit at Silber Bluff, Savannah River.

Copper. *See* Chalcopyrite, Covellite, and Enargite.

Corundum. Occurs more or less abundantly in Archean gneisses and later rocks in Anderson, Cherokee, Laurens, Oconee, Spartanburg, and York counties; Cherokee County, prospected 2 miles north of Gaston Shoals; York County, found in belt 200–300 feet wide in northeastern part of county, between Allison and Crowder creeks, mined 1 mile north of summit of Nannies Mountain.

Corundum. Cherokee County, valuable "oriental emerald" reported in Bowen River region, in Archean gneiss.

Corundum (sapphire). Cherokee County, some gem sapphires have been found in the Bowen River region.

Covellite. Chesterfield County, occurs in Brewer gold mine as a secondary mineral.

Enargite. Chesterfield County, small crystals occur in Brewer mine.

Feldspar. Abbeville County, large masses occur in pegmatites, near Iva; Anderson County, near Easley; Greenville County, in mica mine 8½ miles southeast of Greenville; Oconee County, near Central and Walhalla; Pickens County, high-grade feldspar, near Pickens.

Fuller's earth. The lower Eocene deposits consist largely of this material which is exposed along their marginal line extending across portions of Aiken, Calhoun, Clarendon, Lexington, Sumter, and Williamsburg counties. Mined near Salters, Williamsburg County.

Galena (argentiferous). Was formery mined in Cherokee County, at Cameron mine; and Oconee County, 15 miles north of Walhalla.

Gold (lode). Small production maintained or intermittent from numerous quartz mines in Abbeville, Anderson, Cherokee, Chesterfield, Edgefield, Greenville, Kershaw, Lancaster, Laurens, Newberry, Oconee, Saluda, Union, and York counties.

Gold (placer). Considerable placer gold has been obtained from mines in Cherokee, Chesterfield, Greenville, Pickens, York, and other counties, but is now of little economic importance.

Granite. Quarried: Chesterfield County, 9 miles west of Ruby; Edgefield County, Edgefield; Fairfield County, at Rockton and near Alston; Greenville County, near Greenville; Greenwood County, Ware Shoals and near Greenwood; Lancaster County, near Heath Springs; Laurens County, near High Point and at Gray Court; Lexington County, Casey, Lexington, and near Batesburg; Newberry County, near Newberry; Pickens County, Beverly Station; Richland County, Columbia. Was formerly quarried at various localities in Anderson, Kershaw, Oconee, Union, and York counties.

Graphite (plumbago). Occasional occurrences of graphite in slates of Anderson, Cherokee, Oconee, and other counties. One deposit worked to slight extent.

Hematite (specular iron ore). Occurs in highly metamorphosed Archean and later rocks. Deposits have been worked to small extent but are not of immediate importance.

Ilmenite. Abbeville County, occurs near Calhoun Falls, and in gold-quartz veins.

Infusorial earth. Williamsburg County, dug at Salters Depot.

Lignite (brown coal). Chesterfield County, Whortleberry Branch, north of Cheraw, and near Mount Croghan; Edgefield County, Savannah River; and in Pickens County.

Limestone (building and lime). Occurs at many points in State, especially in western part. Cherokee County, quarried regularly at Limestone Springs, near Gaffney, chiefly for lime, but in part for building stone; has been quarried intermittently near Blacksburg and Grover; Greenwood County, has been quarried near Ware Shoals; Oconee County, 10 miles northwest of Fort Madison, and 4–9 miles northwest of Walhalla.

Magnetite (magnetic iron ore). Occurs associated with hematite in metamorphosed Archean and later rocks. Of possible economic importance. Found also in gold-quartz veins.

Manganese ore. Deposits of economic importance occur in Abbeville County, near McCormick; Greenwood County, 2 miles west of Breezewood and 5 miles south of Greenwood. The McCormick deposit is nodular concretions of psilomelane and pyrolusite.

Marble. Laurens County, quarried for local use 4 miles east of Ware Shoals; Union County, small quantity quarried 12 miles southwest of Union. Occurs also in Cherokee and Oconee counties.

Marl. Dug for local use in Aiken, Bamburg, Barnwell, Berkeley, Charleston, Clarendon, Colleton, Darlington, Dorchester, Florence, Georgetown, Hampton, Horry, Marlboro, Orangeburg, Sumter, and Williamsburg counties. Extensively quarried at Ingleside, Dorchester County, and calcined for the agricultural trade.

Mica (muscovite). Anderson County, occurs near Anderson, Barnes, Denver, and Iva; was formerly mined near Anderson; Greenville County, mined at Reedy River, also 8½ miles southeast of Greenville; Oconee County, occurs near Seneca.

Molybdenite. Lancaster County, occurs in Haile mine.

Monazite. Deposits of commercial value in Anderson, Cherokee, Greenville, Laurens, Oconee, Pickens, and Spartanburg counties. Mined near Gaffney, Cherokee County, and south of Greenville, Greenville County.

Nickel. Saluda County, occurs associated with chalcopyrite and gold at Culbreath mine.

Peat. Horry County, exposed at Myrtle Beach; Laurens County, exposed on Sharpe property, 3 miles northeast of Ware Shoals. Extensive beds along estuarine region of Combahee and Edisto rivers, and elsewhere. Not used.

Phosphate rock. Mined with dredges in Coosaw River tributaries; also mined extensively in the Ashley and Edisto River basins. Occurs in Wando and Cooper River basins, and at Johns Island, Charleston County.

Platinum. Cherokee and Laurens counties, occurs in Cambrian grit.

Polycrase. Greenville County, found 4 miles from Marietta.

Psilomelane (manganese ore). Abbeville County, in mica schists near McCormick; Greenwood County, 2 miles west of Breezewood and 5 miles south of Greenwood; Spartanburg County, 8 miles south of Glenn Springs.

Pyrite (iron pyrites). Mined for gold in Chesterfield County, Brewer mine; Lancaster County, at Haile and Blackburn mines; Spartanburg County, Thompson mine; Union County, West mine; York County, Big Wilson, Ferguson, Magnolia, and other mines.

Pyrolusite (oxide of manganese). Abbeville County, in mica schists near McCormick; Cherokee County, Smith Mountain; Edgefield County, Hard Labor Creek; Greenwood County, near Breezewood and 5 miles south of Greenwood.

Pyromorphite (phosphate of lead). Cherokee County, was found in Cameron mine, 3 miles southwest of Gaffney.

Pyrrhotite. York County, was mined on Nannies Mountain, 11 miles northeast of Yorkville, and is found at several gold mines.

Rutile. Occurs chiefly in Archean gneisses; Newberry County, crystal masses from vicinity of Prosperity.

Sand (building). Dug in Barnwell County at Blackville; Richland County, Columbia. The largest source of supply utilized is found in bed of Pon Pon River above Jehosse Island.

Sand (glass). Dug in Barnwell County at Blackville and Ulmers; Clarendon County, at Pee Dee area.

Sand (molding). Dug in Charleston County, at Charleston; and Richland County, Columbia.

Siderite (spathic iron ore). Cherokee County, found at Cameron mine, 3 miles southwest of Gaffney.

Silver. Lancaster County, very small annual production, mostly from siliceous gold ores of Blackmon and Haile mines.

Soapstone. Formerly quarried to limited extent in Cherokee County, near Gaffney; Chester County, near Halsellville and Chester; Laurens County, near Laurens; Oconee County, Fair View Church, 6 miles northeast of Seneca, and Soapstone Hill, 4 miles northwest of Tomassee; Pickens County, near Central; Spartanburg County, Cedar Springs; York County, at Nation Ford.

Tin. *See* Cassiterite.

Wad (bog manganese). Chester County, occurs in northeastern part of county; York County, 4 miles southeast of Catawba Junction; extensive exposure.

SOUTH DAKOTA.

Amblygonite. Pennington County, has been mined for lithium on the Peerless and other claims 1 mile south of Keystone, on the Tin Queen claim, 1½ miles east of Oreville; occurs in large masses in pegmatite.

Arsenopyrite. Custer County, of frequent occurrence, nearly always auriferous; Lawrence County, mined for gold at Lead, Central City, and Terraville. Large quantities go to waste in tailings from Homestake and other mines.

Autunite. Occurs in pegmatites of Black Hills, near Keystone.

Azurite. Occurs in copper prospects in Black Hills.

Beryl. Large crystals and masses occur in Custer County, in pegmatites with tin and mica; Pennington County, in pegmatites near Keystone.

Bornite (purple copper ore). Occurs in copper prospects in Black Hills.

Brown iron ore. *See* Limonite.

Cassiterite (tin ore). Lawrence County, has been mined in pegmatite at Tinton, and stream tin was mined and shipped from Bear Gulch and other streams near Nigger Hill; Pennington County, has been mined in pegmatites and quartz veins at Hill City and Keystone.

Cement material. Niobrara chalk in eastern and southeastern part of State furnishes excellent Portland cement material; used at Yankton, Yankton County.

Cerargyrite (horn silver). Lawrence County, in Cambrian quartzites and shales, mined at Carbonate and in Trojan and other mines near Portland (Trojan post office).

Cerussite (carbonate of lead). Lawrence County, in Paleozoic rocks at Carbonate; abundant at Galena; has been mined.

Chalcocite (copper glance). Custer, Lawrence, and Pennington counties, occurs in copper prospects in Black Hills.

Chalcopyrite. Lawrence County, occurs in Lead, Terraville, and Central City gold mines, prospects near Nemo and Deadwood; Pennington County, auriferous on Box Elder Creek, prospects near Sheridan and Rochford.

Cinnabar. Pennington County, reported on Victoria Creek a few miles above Rapid City, also was prospected near Pactola and Rochford.

Clay (brick). Loess abundant in extreme southeastern part of State; excellent brick material. Brick clay dug in Brown County, near Aberdeen; Clay County, Vermilion; Grant County, Bigstone; Hughes County, Pierre; Kingsbury County, De Smet; Lawrence County, Deadwood, Spearfish, Englewood, and Lead; Meade County, Sturgis; Pennington County, Hill City and near Rapid City.

Clay (fire). Pennington County, dug near Rapid City.

Clay (kaolin). Custer County, occurs near Custer, in close proximity to marble.

Coal (bituminous). Fall River County, thin beds exposed in Coal Canyon and Bennett Canyon, north of Edgemont. Not of workable character.

Coal (lignite). Lignite beds having a thickness up to 10 feet underlie portions of the northern half of Harding and Perkins counties. Harding County, mined especially near Buffalo and Karinen in Cave Hills; Perkins County, in Slim Buttes, and at Strool.

Columbite. Custer County, has been mined near Laughing Water Creek north of Custer; Lawrence County, Tinton area, and abundant in gold placers in Nigger Hill district; Pennington County, in pegmatites near Hill City, Oreville, Keystone, and in gold placers in Black Hills.

Copper. *See* Azurite, Bornite, Chalcocite, Chalcopyrite, Cuprite, Enargite, and Malachite.

Cuprite (red oxide of copper). Custer, Lawrence, and Pennington counties, occurs in copper prospects in Black Hills.

Enargite. Occurs in copper prospects in Black Hills.

Ferberite. *See* Wolframite.

Fluorspar. Lawrence County, occurs in mines near Portland (Trojan post office), and in considerable quantity in Ulster mine.

Fuller's earth. Custer County, deposits have been worked near Fairburn. Common in the badland beds of Mellette, Pennington, Stanley, Washabaugh, and Washington counties.

Gabbro (black granite). Minnehaha County, quarried near Sioux Falls, takes high polish, and many excellent tombstones and pillars are made.

Galena. Custer County, occurs at Spokane, gold and silver bearing; Lawrence County, small quantity mined in Galena, Perry, and Carbonate districts; Pennington County, in limestone on Box Elder Creek, gold bearing, also in quartz veins near Hayward and Silver City.

Gold (lode). Custer County, free in quartz in Algonkian rocks in Chilkoot mining district near Custer; Lawrence County, mined at Lead, Central City, and Terraville, formerly mined in limestone near Ragged Top Mountain; Homestake mines at Lead produce three-fourths of the gold output of the State; Pennington County, mined in Holy Terror, Keystone, and other mines.

Gold (placer). Dredge at or near Rapid City and near Custer. Custer County, former workings in bed of French Creek, Custer; Lawrence County, Deadwood, Whitewood, Gold Run, and elsewhere in Deadwood district and in Nigger Hill district; Pennington County, Rockerville, Hill City, and Keystone.

Granite. Custer and Pennington counties, immense quantities exposed in Black Hills; Grant County, quarried extensively in Bigstone City.

Graphite. Custer, Lawrence, and Pennington counties, occurs with cassiterite in Black Hills; Custer County, small quantity ground and shipped from Custer; Pennington County, amorphous graphite on Castle Creek and near Hill City, prospecting near Rochford.

Grindstone. Fall River County, excellent grindstones and burrstones quarried from Dakota sandstone near Edgemont.

Gypsum. Plaster mills in Fall River County, at Hot Springs; Lawrence County, Spearfish; Pennington County, Rapid City. Extensive deposits in Butte, Custer, Fall River, Lawrence, Meade, and Pennington counties.

Hematite (red iron ore). Custer County, occurs at Iron Mountain; Pennington County, mine 4 miles south of Keystone, contains gold and silver; abundant on Box Elder Creek, and in slates and quartzites near Rapid City, occurs at Iron Mountain.

Hübnerite. *See* Wolframite.

Infusorial earth. Custer County, extends from high slopes of hills west of Fairburn and Hermosa, east into bad lands; has been mined at Argyle and Fairburn.

Jamesonite. Pennington County, occurs in lead-silver ores near Silver City and Rochford.

Jasper. Minnehaha County, a thick deposit susceptible of high polish; worked to a large extent, especially at Sioux Falls and Dell Rapids; shipped to Omaha, St. Paul, Chicago, and other cities for buildings, pavements, and ornaments. Outcrops locally also in Hanson, McCook, and Turner counties.

Lead. *See* Cerusite and Galena.

Lepidolite (lithium mica). Pennington County, occurs in many pegmatite dikes near Keystone.

Lignite. *See* Coal.

Limestone (building, crushed stone). Quarried in Custer County, near Argyle, for railroad ballast; Lawrence County, at Spearfish; Meade County, Sturgis.

Limestone (chalkstone). Bonhomme County, has been used locally for building in Scotland and Springfield; Davison County, Mitchell; Minnehaha County, Brandon.

Limestone (lime, flux). Excellent lime made from purple limestone in Black Hills region; quarried at Deadwood, Lawrence County, and near Rapid City, Pennington County.

Limonite (brown hematite). Occurs with gold-quartz veins in Black Hills, with other iron ores in Iron Mountain on Pennington-Custer county line; carries gold and silver.

Lithographic stone. Custer County, fine-grained limestone occurs 10 miles west of Custer, also in vicinity of Loring, not used.

Malachite (green carbonate of copper). Custer, Lawrence, and Pennington counties, occurs in copper prospects of Black Hills.

Manganese. *See* Pyrolusite.

Marble. Custer County, extensive deposit occurs in Algonkian schist 4 miles northeast of Custer, was formerly quarried; in Lawrence and Fall River counties; Pennington County, in schist at Box Elder.

Mica (muscovite). Custer County, mined at several places near Custer; Pennington County, formerly mined near Keystone.

Natural gas. Considerable quantities are found in boring artesian wells in Hand County, at Miller; Hughes County, at Pierre, used locally. Small quantity in artesian wells in Lyman County; Spink County, at Ashton; Stanley and Sully counties; Turner County, at Dolton; Walworth County, at Selby.

Ocher (mineral paint). Occurs with iron ores on Iron Mountain on Pennington-Custer county line, 4 miles south of Keystone.

Peat. Tripp County, reported at head of Cottonwood Creek.

Pumice. Occurs at Argyle, Custer County, and in Washington County.

Pyrite. Lawrence County, principal gold-bearing mineral of Black Hills; mined at Lead, Central City, and Terraville; also used as flux in smelting siliceous ores. Large deposits carrying very small quantities of gold, silver, and copper occur on Whitewood Creek near Deadwood.

Pyrolusite. Custer County, disseminated in sandstone at Argyle, has been mined and shipped; Pennington County, occurs also in Algonkian rocks.

Pyrrhotite (magnetic iron pyrites). Lawrence County, in gold-quartz veins at Lead, Central City, and Terraville; contains gold; mined with pyrite for use as flux.

Quartz (rose). Custer County, occurs in Red Rose mine 6½ miles south of Custer; Pennington County, many veins on Harney Peak, and in the vicinity.

Quartzite. Minnehaha County, quarried at Sioux Falls and Dell Rapids.

Sand (glass). Meade County, Unkapapa sandstone on Elm Creek suitable for making glass, but not utilized.

Sand and gravel. Abundant along streams near Black Hills and in eastern part of State. Dug extensively in Beadle County, at Wessington; Brown County, near Aberdeen; Hanson County, near Mitchell; Lincoln County, near Hudson; Minnehaha County, Sioux Falls.

Sandstone. Quarried for local use in Butte County, near Bellefourche; Davison County, on Firesteel and Enemy creeks; Fall River County, near Hot Springs; Harding County, an excellent building sandstone occurs in North Cave Hills; Hutchinson County, 3 miles north of Milltown; Lawrence County, Spearfish; Meade County, near Doyle; Pennington County, near Rapid City.

Scheelite. Lawrence County, occurs with cassiterite and wolframite in Nigger Hill district; Pennington County, in small quantity with cassiterite and wolframite in quartz veins near Hill City.

Silver. Lawrence County, small quantities recovered from gold bullion; argentiferous lead ores at Galena and Carbonate Camp. *See also* Cerargyrite.

Sphalerite (zinc blende). Lawrence County, occurs with gold-quartz veins in Uncle Sam mine near Perry and with lead-silver ores at Galena.

Spodumene. Custer County, occurs in Tin Mountain claim 5 miles west of Custer; Hand County, in vicinity of Glendale; Pennington County, near Oreville, at the northwest base of Harney Peak, and in the Etta claim 1½ miles south of Keystone. A considerable quantity has been mined and shipped from the Etta claim for the manufacture of lithium salts. The crystals at this place are immense, attaining 42 feet in length.

Tantalite. Pennington County, in placers near Keystone.

Tetradymite. Custer County, occurs associated with quartz near Custer.

Tin. *See* Cassiterite.

Torbernite. Pennington County, found near Keystone.

Tungsten. *See* Scheelite and Wolframite.

Uranocircite. Pennington County, found near Keystone.

Volcanic ash. Occurs in workable quantities in the upper badland beds in several counties, especially Mellette, Shannon, and Todd.

Wolframite (tungstate of iron and manganese). Lawrence County, in gold ores at Lead and on Yellow Creek, has been mined and shipped; Pennington County, occurs in quartz veins near Hill City and Keystone. In Pennington County part of the mineral is ferberite and part is hübnerite, but the largest part is probably wolframite.

Wood (petrified). Found in Custer, Fall River, Lawrence, Pennington, and other counties.

Zinc. *See* Sphalerite.

TENNESSEE.

Alum. Abundant in caverns (rock houses) in Cannon, Coffee, Dekalb, Franklin, Giles, Jackson, Lincoln, Overton, and Putnam counties; Sevier County, Alum Cave.

Asbestos. Johnson County, in small quantity.

Azurite. Polk County, Ducktown copper mines.

Barite. Cocke County, has been mined at Del Rio; Davidson County, gangue of lead mine near Haysborough; Green County, 12 miles from Greeneville in veins in dolomite. Monroe County, mined at Sweetwater; Smith County, has been mined near Trousdale, Ferry-Lebanon Road; has been mined also in Bradley, Jefferson, Loudon, McMinn, and Washington counties.

Bauxite. Carter County, mined at Elizabethton; Hamilton County, mined at Missionary Ridge, near Chattanooga, and used chiefly in the manufacture of aluminum salts and compounds.

Bitumen (asphalt). Hickman County, Perrys, on fork of Blue Buck Creek, in seams in limestone.

Brown iron ore. *Limonite.*—Occurs in Benton, Decatur, Dickson, Hardin, Hickman, Houston, Humphreys, Lawrence, Lewis, Montgomery, Perry, Stewart, and Wayne counties; mines at Allens Creek, Ferro, Iron City, Pinkney, Riverside, and West Point.

Brown hematite.—Eastern iron ore region across State from Virginia to Georgia, in Blount, Carter, Cocke, Greene, Johnson, Monroe, Polk, Sevier, Sullivan, and Washington counties. The ores occur in matrix of clay, sand, chert, and débris of disintegrated rocks, mostly in Knox dolomite. Blount and Monroe counties, almost inaccessible; Carter County, Dove River Cove banks; Cocke County, Whitehall, Pecks Mountain, and elsewhere; Greene County, several banks of manganiferous ore near Unaka Furnace; Johnson County, Crockett's, Sharp's, and other banks, south foot of Holston Mountain, Laurel Creek Valley and Butler Furnace banks; McMinn County, Tellico Plains, several deposits; Polk County, in gossan at Ducktown copper mines; Sevier County; Sullivan County, at Crockett bank and other places in eastern part of county; Washington County, deposits in Bompass Cove and Greasy Cove.

Calamine. Claiborne County, overlying Knox dolomite near Tazewell; Hancock County, in many places, with Smithsonite. Jefferson County, associated with smithsonite and blende in Knox dolomite at Mossy Creek; Union County, near New Prospect, and at Stiner's zinc mine; Powell River, with smithsonite in irregular veins in Knox dolomite; occurs at other localities in Bradley, Cocke, Jefferson, Knox, Loudon, Monroe, and Moore counties in valley of east Tennessee.

Calcite. Polk County, Ducktown mines; Smith County, Foley mine 8 miles west of Carthage.

Cement (natural). Hardin County, argillaceous limestone mined at Clifton, good grade natural cement; Knox County, calcareous shales used for natural cement.

Cement (Portland). Limestone along east front Cumberland Plateau, in Sequatchie Valley, and on west front of plateau; mined at Richard City, Marion County. Limestone and shale suitable for Portland cement abundant in eastern and middle Tennessee.

Cerusite. Blount, Bradley, McMinn, Union, Washington, and other counties, secondary mineral of lead ore, not mined; occurs as accessory mineral with galena.

Chalcanthite (blue vitriol). Polk County, small quantity in ores of Ducktown district.

Chalcocite (copper glance). Polk County, small quantity in ores of Ducktown district.

Chalcopyrite (copper pyrites). Polk County, in massive pyrrhotite of Ducktown ore bodies, carries gold and silver.

Chert. Abundant in Knox dolomite in the valley of east Tennessee and in Fort Payne formation (Carboniferous) on edge of basin of middle Tennessee; mined for road metal at Centerville, Hickman County, and elsewhere.

Chert (Camden). Benton County, near Camden.

Chert (novaculite). Used for road making all over west Tennessee.

Clay (brick). Mined in Bedford County, at Shelbyville; Blount County, Maryville and Scottsville; Bradley County, Cleveland; Carroll County, McKenzie; Carter County, Elizabethtown; Cheatham County, Ashland City; Coffee County, Tullahoma; Crockett County, Gadsden; Davidson County, Nashville; DeKalb County, near Smithville; Dickson County, small quantity, Dickson; Dyer County, Dyersburg; Franklin County, Winchester; Gibson County, Brownsville, Eaton, Humboldt, Milan, and elsewhere; Giles County, Pulaski; Greene County, Greeneville and Mohawk; in Grundy County; Hamblen County, Morristown; Hamilton County, Chattanooga; Hardeman County, Bolivar and Whiteville; Henderson County, Lexington; Henry County, Paris and Peryear;

Jefferson County, Jefferson City; Knox County, Byington, Dedie, Edgewood, Knoxville, and elsewhere; Lauderdale County, Gates, Halls, and Ripley; Lawrence County, Lawrenceburg; Lewis County, Hohenwald; Lincoln County Fayetteville; McMinn County, Englewood; Madison County, Gilmore; Macon County, small quantity near Lafayette; Marshall County, Lewisburg; Maury County, Columbia; Monroe County, Sweetwater; Montgomery County, Clarksville; Obion County, Obion, Rives, and Union City; Polk County, Benton; Putnam County, Cookeville; Rhea County, Dayton; Rutherford County, Eagleville and Murfreesboro; Scott County, Robbins; Sevier County, Sevierville; Shelby County, Memphis and New South Memphis; Sullivan County, Bristol; Sumner County, Portland; Tipton County, Covington; in Van Buren County; Warren County, McMinnville; Weakley County, Gleason, Greenfield, and Martin; White County, Sparta; Wilson County, Lebanon.

Clay (fire). Has been mined in Bradley County, at Cleveland; Carroll County, at McKenzie; Hamilton County, St. Elmo; Henry County, Peryear; Houston and Stewart counties; in district between Central Basin and Tennessee River; Knox County, Powell Station; Madison County, Gilmore and Pinson; Putnam County; Rhea County, near Evansville; Roane County, Oliver Springs.

Clay (kaolin). Carroll and Carter counties, small quantities; Henry County, Sparta; Stewart County, has been mined at Tennessee kaolin mines.

Clay (pottery). Carroll County, near Hico and Hollow Rock; Fayette County, LaGrange; Hardeman County, Grand Junction; Henry County, Peryear (ball clay) and Henry; James County, Summit; Madison County, Pinson; Rhea County, Graysville.

Clay (stoneware). Cocke County, has been mined at Del Rio; Putnam County, small quantity formerly mined at Silver Point; Weakley County, formerly mined near Gleason.

Coal (bituminous). The State is divided into two districts, the northern and southern, by the Tennessee Central Railway. These are also known as the Jellico and Chattanooga districts. The Jellico coal district is divided into the northeastern and northwestern fields by the Queen & Crescent Railway. Northeastern field, between Queen & Crescent Railway and Cumberland Mountain escarpment. Coal is mined at the following places: Anderson County, Briceville, Coal Creek, and Windrock; Campbell County, Anthras, Block, Careyville, Chasca, Cotula, Cupp, Elk Valley, Jellico, Kimberley, Lafollette, Morley, Newcomb, Peabody, Remy, Rich Mountain, Red Ash, Turley, Westbourne, Wynn; Claiborne County, Clairfield, Egan, Fonde, Fork Ridge, Hartranft, Nicholson, and Pruden; Morgan County, Coalfield, Petros, and State mines; Roane County, Oliver Springs and Rockwood; Scott County, Almy, Glenmary, Helenwood, Laxton, and LeMoyne. Northwestern field, north of Tennessee Central and west of Queen & Crescent Railway, includes parts of Cumberland, Fentress, Morgan, Overton, Pickett, Putnam, and Scott counties. Coal mined at the following places: Cumberland County, mined at Isoline, formerly mined at Fall, Millstone, and Mammys creeks, east side of Crab Orchard Mountain, and attempted at Crab Orchard but abandoned because too badly crushed; Fentress County, Wilder; Overton County, Crawford, Obey City, and old Murdock opening 1 mile south of Cook Place; Scott County, Bear Creek. Southern field, south of Tennessee Central Railway, includes nearly all of Bledsoe, southern Cumberland, Grundy, Marion, Sequatchie, and Van Buren counties, eastern part of White County, and western Hamilton, Rhea, and Roane counties. Bledsoe County, mined at Atpontley and on Stephen Gap Road, and has been opened at numerous places along west boundary of the county; Cumberland County, coal worked only for local use at small banks; Franklin County, formerly mined at Sewanee, worked out; Grundy

County, mined at Coalmont, Clouse Hill, and Tracy City; Hamilton County, mined at Montlake, Sales Creek, Soddy, and every few miles on Walden Ridge; Marion County, mined at Orme and Whitwell, large body of coal undeveloped by lack of transportation; Rhea County, mined at Dayton, Grand View, and Graysville; Sequatchie County, mined at Dunlap; Van Buren County, mined at Gillentine, Oleo, Roverton Springs, Spencer, and at many small banks for local use; White County, mined at Bon Air, Eastland, and Ravenscroft.

Coal (lignite). *See* Lignite.

Cobalt. Hickman County, in wad at numerous points near Centerville.

Copper. *See* Azurite, Chalcanthite, Chalcocite, Chalcopyrite, Cuprite, Malachite, Melaconite, and Tetrahedrite.

Cuprite. Polk County, small quantity in ores of Ducktown district.

Dolomite. Knox dolomite very abundant in east Tennessee, quarried and dressed for structural work.

Epsomite. At many places with alum and copperas; Sevier County, Alum Cave.

Flagstone. *See* Limestone and Sandstone.

Fluorspar. Carter County, Watauga Point; Smith County, Foley mine, about 8 miles west of Carthage; Trousdale and Wilson counties, small quantities mined.

Galena (lead ore). Bradley County, 20 miles east of Chattanooga and at Blue Springs 6 miles south of Cleveland, has been mined at latter place; Claiborne County, Straight Creek, 5 miles southwest of New Tazewell, has been mined with zinc; Davidson County, has been mined; Polk County, in minute quantities in ore bodies of Ducktown mines; Washington County, disseminated in grains in rock of Bompass Cove; Williamson County, has been mined near Nolansville; also found in Blount, McMinn, and Union counties.

Gold (placer). Blount County, has been mined in Montvale Springs and back of Chilhowee Mountain; Monroe County, Coker Creek; Polk County.

Gold (lode and placer). Monroe County, Whippoorwill Branch of Tellico River, has been mined.

Gold. By-product from copper ores.

Granite. Max Patch and Cranberry granites in Carter, Cooke, Greene, Johnson, and Unicoi counties; Carter County, Ripshin Mountain on Doe River.

Graphite. Knox County, with zinc ores, in small quantities; Polk County, associated with copper ores, Ducktown.

Gypsum. In small quantities in many caves; Grays Cave, northern part of Sumner County.

Halite (common salt). Salt has been worked in White County, 3 miles from Sparta; Overton County, at Obey River. Brine has been found in most of borings for petroleum in middle Tennessee, in Anderson, Jackson, Overton, Van Buren, and Warren counties.

Hematite. Occurs in Bledsoe, Bradley, Campbell, Claiborne, Cocke, Grainger, Hamilton, Hancock, Henderson, James, Loudon, Marion, McMinn, Monroe, Rhea, Roane, Sequatchie, and Sullivan counties. Mined in Carter County, Stony Creek Valley; McMinn County, east of Athens.

Iron. *See* Brown iron ore, Hematite, Magnetite, and Pyrite.

Lead. *See* Cerusite and Galena.

Lignite. In Eocene deposits of west Tennessee; extensive in Dyer, Johnson, Lauderdale, Obion, Shelby, and Tipton counties.

Limestone. Quarries: Bradley County, Charleston; Cumberland County, Crab Orchard; Davidson County, Newsom Station, Fuller's Siding, and Nashville; Decatur County, Perryville; Franklin County, Sherwood; Giles County, Aspen Hill; Hamilton County, East Chattanooga and Chickamauga; Houston County, Erin; Jefferson County, Straw Plains; Knox County, Knoxville; Lawrence County, very small quantity quarried at Lawrence; Marion County, Hales

Bar Dam near Chattanooga; Marshall County, Chapel Hill; Maury County, Columbia; Overton County, Windle; Roane County, Rockwood; Robinson County, Adams; Rutherford County, Eagleville; Sullivan County, Bluff City; Sumner County, near Goodlettsville; White County, Doyle; Wilson County, Lebanon.

Limestone (flagging). Quarried: Knox County, near Knoxville, blue flags; Morgan County, near Montgomery; Wilson County, Lebanon.

Limestone (flux). Quarried: Carter County, Milligan; Claiborne County, Cumberland Gap; Hickman County, Bon Aqua; James County, Ooltewah; Montgomery County, Clarksville; Rhea County, Dayton; Roane County, Rockwood; Washington County, Embreeville.

Limonite. *See* Brown iron ore.

Lithographic stone. Clay, Jefferson, McMinn, and Overton counties; Putnam County, at Algood.

Magnetite. Blount County, float found in eastern part of county; Carter County, in older rocks of mountain spurs near Crab Orchard Valley; Cocke and Unicoi counties.

Malachite. Monroe County, Buck Miller mine; Polk County, small quantities in ores of Ducktown district.

Manganese. Bradley County, 9 miles from Cleveland; Cocke County, in vicinity of Newport and Del Rio; Johnson County, Shady Valley; Unicoi County, Unicoi. Small deposits reported from Carter, Greene, and Sevier counties; Hamblen County, near Morristown; and Hickman County, has been mined at Whitefield. *See also* Psilomelane, Pyrolusite, and Wad.

Marble. Abundant in State; occurs in Blount, Claiborne, Grainger, Hamlen, Hancock, Hawkins, Knox, Loudon, McMinn, Monroe, Roane, Sevier, and Union counties. Quarried in Blount County, near Knoxville, Knox County, Caswell and Concord, and at confluence of French Broad and Holston rivers; Hawkins County, has been quarried at Rogersville; Union County, Luttrell. Marbles are also found in Franklin, Greene, Lincoln, Washington, and other counties.

Marble (onyx). Small quantity found in caves, especially in Anderson and Claiborne counties.

Marl. Greensand associated with Selma chalk in western part of State.

Melaconite (black copper). Polk County, mixed with chalcocite in Ducktown copper mines.

Mineral paint. Oxides and carbonates of iron, lead, and zinc ore are so used; supply from Bradley, Cheatham, and James counties.

Natural gas. Bedford, Cumberland, southwestern Davidson, Dickson, Franklin, Lincoln, Marshall, Maury, Sumner, and White counties; production small.

Niter (saltpeter). In caves in limestone region; large quantities mined during War of 1812 and Civil War.

Novaculite. *See* Chert.

Onyx marble. *See* Marble (onyx).

Peat. Hardin, Henry, and Tipton counties; not used.

Petroleum. Dickson County, in black Chattanooga shale on Jones Creek; Overton County, Netherland, Spring Creek, and Eagle Creek; Putnam County, near Algood; Scott County, near Glenmary; no producing wells since 1908. Fentress and Pickett counties, in Spurrier-Riverton district; also in Clay, Franklin, and other counties.

Phosphate rock. Davidson County, near West Nashville; Decatur County, Parsons; Giles County, Wales; Hickman County, Centreville, Fogg, and Swan Bluff; Lewis County, Big Swan; Maury County, Mount Pleasant, near Columbia, Ewell Station, Kleburne, and elsewhere; Perry County, Lick Creek;

Putnam County, Boma; Sumner County, Gallatin and Rogana; Williamson County, Brentwood, and near Franklin.

Potash. *See* Niter.

Psilomelane. Cocke County, Yellow Springs mine, near Newport.

Pyrite. Carter County, in black shale on Stony Creek, 12 miles northeast of Elizabethtown, has been mined; Cheatham, Greene, and Moore counties, large quantities have been found; Polk County, as stringers and particles in ore bodies of Ducktown mines, bearing gold and silver.

Pyrolusite. Has been mined in Carter County, near Elizabethtown; Cocke County, near Newport and Del Rio; Johnson County, in iron and manganese ores at Shady Valley; Monroe County, irregular masses with iron ores near Sweetwater; Unicoi County, near Unicoi in limestone.

Pyrrhotite. Polk County, principal sulphide of Ducktown district, bears gold and silver.

Salt. *See* Halite.

Sand (building). Dug in Carter County, at Elizabethtown and Watauga; Davidson County, Mackie; Fayette County, LaGrange; Franklin County, Estell Springs; Hamilton County, Chattanooga and St. Elmo; Hardeman County, Saulsbury; Knox County, Knoxville; Lincoln County, near Fayetteville; Loudon County, Lenoir City; Roane County, Harriman and Rockwood; Shelby County, Memphis; Sullivan County, West Bristol.

Sand and gravel. From bottom of Mississippi, Tennessee, and Cumberland rivers, in Benton, Carter, Davidson, Decatur, Hamilton, Johnson, Knox, Rhea, Roane, and Shelby counties.

Sand (glass). Great quantities of sandstone suitable for crushing: Anderson County, Coal Creek; Benton County, saccharoidal sandstone; Blount County, Chilhowee; Hardeman County, Saulsbury; Knox County, Knoxville; Montgomery County; Sullivan County, 20 miles from Bristol.

Sand (molding). Davidson County, near Nashville; Franklin County, Estell Springs; Hamilton County, Chattanoooga; Hardeman County, Saulsbury; Henry County, Paris; Knox County, Knoxville; Loudon County, Lenoir City; Madison County, 4 miles west of Jackson; Rhea County, Dayton.

Sandstone. Bledsoe County, near Pikesville; Blount County, Chilhowee; Franklin County, Sewanee and side of Lookout Mountain; Hawkins County, Clinch Mountain; White County, along west side of plateau.

Sandstone (flagging stone). Abundant in counties of eastern Highland Rim; Macon County, at Lafayette, sometimes used for buildings; used for foundations in western Tennessee.

Shale. For paving and other brick; has been mined in Anderson County, at Donovan; Roane County, Rockwood. For wood-fiber plaster, in Campbell County, at Jellico Plains.

Siderite (clay ironstone, carbonate of iron). Anderson County, below Wiley coal bed; Grundy County, Beersheba Springs, and other localities; Houston County, Coal Creek and Caryville, Wells Creek Basin.

Silver. By-product with copper and lead ores.

Slate. Vast supply of metamorphosed slates in extreme eastern counties; quarries along Little Tennessee River, Knox County; Blount, Cocke, McMinn, Monroe, Polk, and Sevier counties.

Smithsonite (carbonate of zinc, "dry bone"). Claiborne County, overlying Knox dolomite near Tazewell; Hancock County, occurs with calamine, abundant; Jefferson County, Mossy Creek and New Market, mined extensively; Union County, near New Prospect; other localities in valley of east Tennessee.

Sphalerite (zinc blende). Claiborne County, in Knox dolomite near Tazewell; Jefferson County, mined at New Market; Knox County, mined extensively near Mascot; Smith County, with calcite and fluorspar near Trousdale, Ferry-Lebanon Road; Union County, in Knox dolomite, near New Prospect.

Sulphur. Polk County, obtained from reduction of copper, used for sulphuric acid. *See also* Pyrite and Pyrrhotite.

Tetrahedrite (gray copper ore). Monroe County, Buck Miller mine; mouth of Coco Creek, on Hiwassee River; argentiferous.

Wad. With manganese ore in Cocke County, near Newport and Del Rio; Johnson County, in Shady Valley; Unicoi County, near Unicoi.

Zinc. *See* Calamine, Smithsonite, and Sphalerite.

TEXAS.

Agate. Brewster County, at many localities north and south of Alpine, especially at Agate Hill, on the Terlingua road, 20 miles south of Alpine, and on the Kokernut ranch, northeast of Alpine; Presidio County, on the Bogel ranch, 12 miles south of Marfa, many beautiful colors, blue, blue-gray, red, and white.

Allanite. Llano County, at Barringer Hill and near Kingsland; some specimens contain much occluded hydrogen.

Alum (native). Brewster County, northwest of the Chisos Mountains; Presidio County, Fresno Canyon, 80 miles south of Marfa.

Amethyst. In Burnet, El Paso, and Llano counties.

Asbestos. El Paso, Gillespie, and Llano counties; has not been found in commercial quantities.

Asphalt. Bituminous sandstones and limestones in the following counties: Anderson, Angelina, Brewster, Burnet, Coke, Cooke, Hardin, Hunt, Jack, Jasper, Martin, Montague, Nacogdoches, Panola, Pecos, San Augustine, Stephens, Travis, Uvalde. The bituminous limestone from Uvalde County has been used for paving in San Antonio, and also as a source of lithocarbon (a bitumen extracted from the rock with naphtha); the bituminous sandstone from Montague County also has been used for paving. The principal source of asphalt in Texas now is the residuum from the distillation of crude petroleum.

Barite. Llano County; also reported from Burkeville, Newton County.

Borax. Small quantity as incrustations in old shallow lakes in western Texas, El Paso County.

Brown iron ore (brown hematite, limonite). There are many localities in eastern and northeastern Texas which afford an excellent limonite for blast-furnace use. The principal counties are: Anderson, Cass, Cherokee, Gregg, Henderson, Marion, Morris, Nacogdoches, Panola, Rusk, Shelby, Smith, Upshur, and Wood. A special iron-ore dock was built at Port Bolivar, Galveston Bay, in 1912, for handling ocean shipments of iron ore and a good deal of active prospecting work is in progress.

Cassiterite. El Paso County, in Franklin Mountains 14–16 miles north of El Paso, where it is worked for tin, in aplite dikes cutting granite; Mason County, reported from Herman and Willow creeks.

Celestite. Burnet County, at Strickling; Lampasas County, 5 miles north of Lampasas, in large crystals filling pockets in Glen Rose limestone; San Saba County; Travis County, on Mount Bonnell, Colorado River, near Austin.

Cement material. Limestones and shales widely distributed over the State. Eagle Ford shale and Austin chalk used near Dallas and San Antonio; Cretaceous limestone and shale used at El Paso.

Chalcocite. Considerable quantities from the Permian in Archer, Foard, Haskell, Jones, Knox, and Stonewall counties, mostly in nodular form in these beds and carrying from 50 to 60 per cent of copper. Found also in El Paso and Llano counties.

Chalcopyrite. Burnet County; El Paso County, west side of Quitman Mountains, from which shipments have been made, and Sierra Diablo; also in Culberson and Llano counties. The most promising localities are in the Quitman Mountains and the Sierra Diablo, El Paso County.

Cinnabar. *See* Quicksilver.

Clay (brick). Many varieties widely diffused over the State. Used chiefly for common brick, sewer pipe, drain pipe, fire brick, also used for making ordinary pottery. The principal counties are: Anderson, Bastrop, Bexar, Bowie, Brewster, Brown, Cameron, Coleman, Collin, Cooke, Dallas, Denton, Ellis, El Paso, Erath, Falls, Fayette, Fort Bend, Gonzales, Grayson, Guadalupe, Hall, Hardin, Harris, Harrison, Henderson, Hidalgo, Hill, Hopkins, Hunt, Jefferson, Johnson, Jones, Lamar, Lee, Leon, Limestone, McLennan, McMullen, Marion, Maverick, Medina, Milam, Montague, Nacogdoches, Navarro, Orange, Panola, Parker, Polk, Potter, Rains, Red River, Robertson, San Augustine, Shelby, Smith, Tarrant, Taylor, Titus, Tom Green, Travis, Upshur, Valverde, Van Zandt, Walker, Washington, Webb, Wharton, Wichita, Williamson, Wilson, Wise, Wood, Young. The clay in Brewster County is used in a yard 130 miles from the railroad for making brick for the quicksilver furnaces in the Terlingua district.

Clay (kaolin). Edwards County, about 6 miles west of the little town of Leakey, a considerable deposit of high-grade kaolin from which excellent china and porcelain wares have been made. Kaolinite has been reported from Nueces County, but very little is known about the locality.

Coal. Bituminous coal is mined in the following counties: Erath, Jack, Palo Pinto, Parker, Wise, and Young in the North Central coal field, and in Maverick and Webb in the Rio Grande coal field. The coals of the North Central field are true Carboniferous coals (Pennsylvanian); the Rio Grande coals have been regarded as late Cretaceous or early Tertiary. Besides the counties enumerated as producing coal at the present time in the North Central field, workable beds also occur in Brown, Coleman, Comanche, Eastland, McCulloch, Montague, and Stephens counties. The total workable coal area is about 8,200 square miles, with an additional area of 5,300 square miles which may contain workable beds. *See also* Lignite.

Cyrtolite. Llano County, occurs sparingly in pegmatite at Baringer Hill, mined with other yttrium minerals.

Eglestonite. Brewster County, occurs sparingly, with other quicksilver minerals, in the Terlingua district.

Fergusonite. Llano County, occurs sparingly at Baringer Hill.

Fluorspar. Brewster County, sparingly, in association with quicksilver deposits; Burnet County, Spring Creek drainage basin; Gillespie County, near Enchanted Rock; Llano County, at Baringer Hill.

Fuller's earth. Extensive deposits of excellent fuller's earth are found in Burleson, Fayette, Smith, and Washington counties, and the deposits in Smith County extend also into Cherokee County; some of the deposits in Fayette County are worked.

Gadolinite. Burnet County, in small quantity, except in one instance, is found in red granite area; Llano County, at Baringer Hill. Used in making the glower in the Nernst electric lamp.

Galena. Brewster County, in the Solitario, excellent material; Burnet County, in calcareous sandstone on Silver Creek; Coleman County, in a conglomerate near Santa Ana; El Paso County, on both sides of the Quitman Mountains, associated with ores of copper and zinc; Knox County, associated with ores of copper and zinc in the Permian; Presidio County, at Shafter, with silver ores in San Antonio Canyon and southwest of the Chinati Mountains, good material.

Gold. Occurs sparingly in Llano County.

Granite. Burnet County, red granite quarried extensively at Granite Mountain 2½ miles north of Marble Falls and gray granite at localities west of the town of Burnet; El Paso County; Llano County, near Kingsland and Llano; many excellent and beautiful varieties. Opaline granite (granite porphyry) occurs near Llano; it is a most beautiful and attractive stone, but has not been placed on the market.

Graphite. Burnet and Llano counties, prospected to some extent but not mined commercially; in schist at Lone Grove 7 miles east of Llano.

Gypsum. At many localities in the State, especially in the Permian rocks west of the Pennsylvanian area of rocks. Brewster County, curious forms of gypsum, curved and twisted like a ram's horn, occur in association with quicksilver deposits in the Terlingua district; Hardeman County, mined at Acme and Quanah; much Keenes plaster is made from the gypsite beds; Jones County, mined at Hamlin; Stonewall County, extensive deposits of good alabaster are reported from the northeastern corner of the county at Kiowa Peak in beds up to 4 feet thick; Nolan County, rose gypsum occurs near Sweetwater in beautiful forms and colors. The eastern border of the Permian area contains extensive beds of gypsum, and gypsum has been found in deep borings along the Gulf of Mexico.

Hematite. Llano and Mason counties, associated with the magnetite ores. *See* Magnetite.

Ilmenite. Llano County, at Baringer Hill and east of Cold Creek; Mason County, at Fly Gap and north of Pontotoc.

Jasper. Brewster and Presidio counties, occurs with agate, chalcedony; Jeff Davis County, near Fort Davis; Llano County, on Pennington and Sandy creeks; Uvalde County, near Montell.

Kleinite. Brewster County, occurs very sparingly in association with rare quicksilver minerals, montroydite, eglestonite, terlinguaite, in the Terlingua district.

Lignite. The lignite area in Texas is probably about 60,000 square miles. The lignite deposits are, for the most part, confined to the Tertiary and they occur on the Gulf slope, from the Red River to the Rio Grande, in an area 650 miles in length and 200 miles in width. In thickness the beds run to 15 feet and more. The counties in which workable beds of lignite occur are the following: Anderson, Angelina, Atascosa, Bastrop, Bowie, Brewster, Caldwell, Camp, Cass, Cherokee, Dimmit, Fayette, Freestone, Grimes, Harrison, Henderson, Hopkins, Houston, Jasper, Lee, Leon, Limestone, McMullen, Marion, Medina, Milam, Morris, Nacogdoches, Newton, Panola, Rains, Robertson, Rusk, Sabine, San Augustine, Shelby, Smith, Titus, Upshur, Van Zandt, Webb, Wood, and Zavala. The lignite producing counties are: Bastrop, Fayette, Henderson, Hopkins, Houston, Lee, Leon, Medina, Milam, Rains, Robertson, Van Zandt, and Wood. During the last few years there has been a marked increase in the use of lignite for making producer gas. The total engine horsepower thus generated is about 13,000, one establishment alone having 4,400 horsepower obtained from lignite gas. There are no establishments in the State making briquets from lignite, but the matter is now under serious consideration. Some of the Texas lignites make a good briquet without a binder.

Limestone and lime. Limestones in great variety of texture and composition occur in many localities. The principal quarries are in the following counties: Bell, Bexar, Bosque, Brown, Coleman, Collin, Comal, Comanche, Coryell, Dallas, El Paso, Erath, Grayson, Guadalupe, Jack, Jones, Kaufman, Lampasas, McCulloch, Nolan, Palo Pinto, Runnels, San Saba, Smith, Tarrant, Travis, Williamson. These localities also afford lime, but the chief lime-producing counties are Bexar, Comal, El Paso, San Saba, Williamson. The pure white limestones of Bexar and Williamson counties are much used for building and have the advantage of being easily sawed into shape by hand.

Limonite. *See* Brown iron ore.

Mackintoshite. Llano County, occurs sparingly at Baringer Hill, in association with other rare minerals, such as yttrialite, nivenite, fergusonite, gadolinite.

Magnetite. Llano and Mason counties, the iron ores are principally magnetite with some hematite. Some of these ores are of good quality but a commercial quantity has yet to be proved. The principal localities are Iron Mountain, the Boder tract, and the Olive mine, Llano County, and places between Iron Mountain and Llano River. At the old Olive mine there is a shaft 300 feet deep and some shipments were made many years ago to the Birmingham district, Ala., and to the State Furnace, Rusk, Cherokee County. High-grade magnetite is to be seen on the surface at Iron Mountain and some work has been done in prospecting the underground ore.

Marble. El Paso County, at Marble Canyon in the Eagle Mountains; Brewster County, south of the Southern Pacific Railroad and about 14 miles from Alpine, beds of white, faint bluish-white, black, and black and white marble of superior quality; this deposit has been prospected to some extent. Llano County, some work has been done on several ledges near the town of Llano, and recent reports indicate the existence of workable beds in other parts of this county. San Saba County, near the town of San Saba, some development work has been done on ledges of pale gray and reddish marble. In association with the gray and reddish marble of San Saba County there occurs a beautiful silver black and golden onyx; polished slabs of this material have been prepared. No commercial marble is now produced in Texas.

Mica. El Paso County, north of Dahlberg, there is a deposit of mica which has been developed to some extent; Mason County, reported from the eastern part of county.

Montroydite. Brewster County, occurs sparingly in association with other rare quicksilver minerals, eglestonite, terlinguaite, and kleinite, in the Terlingua district.

Natural gas. Clay County, chief supplies from Petrolia (Henrietta) field, from which it is piped to Fort Worth, Dallas, Wichita Falls and many other north Texas cities and towns, through distances of 25 to 125 miles: McMullen County, there is much gas near Crowther; Maverick County, gas has been prospected: Navarro County, gas at Corsicana is used locally; Shackelford County, wells at Moran supply local demand, and this gas will probably be piped to Cisco and Albany; Webb County, wells (Reiser) supply Laredo; Texarkana and Marshall are supplied from Caddo, La. The natural gas in association with petroleum is used locally in many of the oil-producing districts, Spindletop, Sour Lake, Saratoga, Humble, Markham, Goose Creek. An important feature of the natural-gas industry in Texas is its competition with producer gas made from lignite.

Nivenite. Llano County, occurs sparingly with other rare minerals at Barringer Hill. *See also* Fergusonite, Gadolinite, and Mackintoshite.

Onyx marble. San Saba County, silver, black and golden onyx occurs with gray and red marble.

Petroleum. Widely distributed in Texas, the producing counties being: Clay, Duval, Hardin, Harris, Jefferson, Matagorda, McCulloch, McMullen, Navarro, and Wichita. A producing well between Jefferson and the Louisiana line, may be in Texas in Marion County. Oil is known to exist in many other counties but producing wells have not yet been brought in; these counties are Brewster, Brown, Coleman, Gonzales, Reeves, Smith, Walker, Wood. The Coastal Plain oils in the counties of Hardin, Harris, Jefferson, and Matagorda are generally of heavier gravity than the interior oils, such as in Navarro and Wichita counties, although there is also a heavy oil in Navarro County (Powell field). Lubricating oil in small quantities is yielded by some wells in Bexar County, near San Antonio, also in Brown and McCulloch counties. The oil from the later fields (Wichita County) is much lighter than the oil from the Coastal Plain; it probably comes from an entirely different geologic horizon, the Pennsylvanian. The Coastal Plain oils are probably from Tertiary. It is likely that country south, southwest, and west of Wichita County, will be found to be oil bearing in localized anticlines. Texas produced 9,526,474 barrels of petroleum in 1911.

Polycrase. Llano County, at Baringer Hill, in pegmatite.

Pyrite. In a great many localities, but so far as known not in commercial quantities. It is widely distributed in Cretaceous limestones and in clays associated with beds of lignite. An interesting occurrence of this mineral is with cinnabar, in the Terlingua district, Brewster County, where some of it carries a little gold. In the Cretaceous bituminous shales of that district pyrite sometimes forms the greater part of the ore carrying quicksilver, and this is particularly the case with the cinnabar in Maverick Mountain, where the veins are in trachyte and andesite. Llano County, prospected at the eastern base of Riley Mountain; also disseminated in pre-Cambrian schists and quartz in Llano and Burnet counties.

Pyrolusite. Dickens County, some high-grade material has been found, but the locality has not been developed; Mason County, Spiller mine, 15 miles northeast of Mason, not developed.

Quartz. Abundant all over the State. Fayette County, in fine but small crystals; Llano County, at Baringer Hill, a fairly well developed crystal weighing 700 pounds was found. Rose quartz has been used for ornament. *See also* Agate.

Quicksilver. Brewster County, Terlingua district, in Cretaceous limestones and shales, as cinnabar, terlinguaite, montroydite, eglestonite, kleinite, and native quicksilver. A single cavity in limestone yielded 150 pounds of native quicksilver; has also been observed as a sort of quicksilver sponge in hard limestone. With the exception of terlinguaite, none of the rare quicksilver minerals has been found outside of the limestone area. The bituminous shales have not been found to carry any of these minerals except terlinguaite, nor has any native quicksilver been found in them. The quicksilver localities are from 90 to 130 miles from rail, the Southern Pacific Railroad at Marathon, Alpine, and Marfa being the nearest. The Terlingua district has yielded about 47,000 flasks of quicksilver, valued at about $2,000,000, and active operations are still carried on. In Presidio County, immediately west of Brewster County, quicksilver ores have also been found, and some prospecting was carried on for a while; but all of the production of this metal in Texas is to be credited to Brewster County.

Rowlandite. Llano County, occurs sparingly at Baringer Hill with nivenite, fergusonite, yttrialite, and gadolinite.

Salt. Produced from brines in Anderson, Mitchell, and Van Zandt counties. There are old lake beds in Crane, El Paso, and other counties which afford a certain amount of crude salt used for stock. A bed of coarse rock salt at the old Brooks Saline, southwestern part of Smith County, has been used as a source of brine for many [redacted] locality a water has been found which [redacted] per gallon—a much larger proportion than has been found in any deep well water in the United States. Some of the oil wells in the Coastal Plain have shown the presence of salt deposits, but no salt is obtained in Texas from such localities. During the Civil War and previous thereto a good deal of salt was made at the old Brooks Saline, previously referred to, as also at the Steen Saline, 14 miles north of Tyler, Smith County. From the records of those days it has been ascertained that the Brooks saline water yielded a bushel of salt from 300 gallons, and that the yield from the Steen water was a bushel of salt from 190 gallons of water.

Sand and gravel. The producing counties are Bastrop, Bexar, Bowie, Coleman, Colorado, Dallas, Ellis, El Paso, Erath, Fayette, Galveston, Grayson, Gregg, Harris, Jefferson, McLennan, Milam, Navarro, Tarrant, Travis, Waller, Webb, and Wilson. Coleman County, at Santa Anna, there is a large deposit of pure sand under Cretaceous limestone. Walker County, 8 miles northwest of Huntsville, fine deposit of white quartz sand from disintegration of a ledge of coarse sandstone. The greater part of this deposit is composed of transparent and translucent particles of quartz, the grains varying in size from $\frac{1}{16}$ to $\frac{1}{4}$ inch.

Sand (glass). Grayson County, dug at Denison.

Sand (molding). Dug in Liberty County, at Liberty; Tarrant County, at Fort Worth.

Sandstone. The producing counties are Burleson, Burnet, Fayette, Grimes, Lampasas, Lavaca, Mills, Montague, Palo Pinto, Polk, Tom Green, Tyler, and Ward. Ward County, red sandstone near Barstow, has been used extensively for building. Lampasas County, one of the best undeveloped properties is a gray stone at Chadwicks Mill.

Serpentine. Gillespie County, in the northeastern part there is an excellent serpentine, affording many varieties of color and texture; polished slabs, spheres, columns, lamp stands, have been prepared from this material, but it is not on the market.

Silver. Brewster County, argentiferous galena has been mined near Altuda. A piece of silver ore from the Chisos Mountains carried 1,100 ounces of silver per ton, but the locality from which it came has not been revealed by the finder. El Paso County, silver-bearing copper ores have been mined in the Sierra Diablo, and values up to 2,000 ounces of silver per ton have been recorded (old Hazel mine); also in galena, associated with ores of copper and zinc in the Quitman Mountains. Presidio County, The Presidio Mining Co. has been mining and milling silver ore for nearly 30 years; the ore carries silver chloride, and with it is associated a galena which carries silver and a little gold. A little native silver has been found at Shafter in thin sheets accompanying silver chloride. In a galena from the San Antonio Canyon, south of the Chinati Mountains, and from near Candelaria.

Smithsonite. El Paso County, near Eagle Flat, shipments have been made; Presidio County, in considerable quantities about 2 miles west of Shafter.

Sphalerite. Burnet County, occurs sparingly with fluorite; El Paso County, east side of the Quitman Mountains with galena and chalcopyrite in old Bonanza mine, has been mined and concentrated; Montague County, small but excellent pieces have been found near St. Jo, in calcite.

Strontianite. Travis County, on Mount Bonnell, Colorado River, near Austin.

Sulphur. From many of the deep borings in the Coastal Plain. Brazoria County, sulphur has been reported and extensive operations have been planned and are in progress (1913) near the mouth of the Brazos River; Culberson County, in the northeastern and eastern part (cut off from El Paso County) there are [illegible] extensive deposits of native sulphur in gypsum and decomposed limestone; [illegible] of this sulphur have been melted out of the containing rock by means of superheated water, and the quality is excellent. This area has been prospected by means of open cuts, pits, boreholes, and sulphur has been found to a depth of 40 feet; 30 feet of this material carries 25 per cent of sulphur. Pecos County, deep wells 15 miles northeast of Fort Stockton; Smith County, a sand containing 10 per cent of native sulphur was found at a depth of about 200 feet at the old Brooks Saline, southwestern part of county.

Talc. Llano County, an impure variety of talc (soapstone) occurs east of Valley Springs; it has been used locally but has not been marketed to any extent.

Tengerite. Llano County, occurs at Baringer Hill, with nivenite, yttrialite, fergusonite, and gadolinite.

Terlinguaite. Brewster County, with montroydite, eglestonite, kleinite, in the Terlingua quicksilver district. It is the only one of the rare mercury minerals found outside of the limestones.

Thorogummite. Llano County, occurs at Baringer Hill.

Tin. *See* Cassiterite.

Topaz. Mason County, with cassiterite and blue feldspar near Streeter; some fine crystals have been cut and polished.

Turquoise. El Paso County, a 4 to 6 inch seam near Van Horn, has been mined.

Wolframite. Culberson County, the most promising locality appears to be near the Figure 2 ranch, 32 miles north of Van Horn; prospecting work in progress in 1913; samples of the material have carried as much as 17 per cent of tungstic oxide. El Paso County, occurs with cassiterite 12 to 15 miles north of El Paso.

Yttrialite. Llano County, at Baringer Hill, with nivenite, fergusonite, gadolinite.

Zinc. *See* Smithsonite and Sphalerite.

UTAH.

Alunite. Piute County, large deposit near Marysvale.

Anglesite. Juab County, occurs in mines of the Tintic district; Summit County, common in Park City mines.

Antimony. *See* Stibnite.

Argentite (silver glance). Juab County, some of the mines of the Tintic district; Piute County, occurs in small quantities in Annie Laurie vein.

Asphalt. Salt Lake County, occurs in Rozel Hills, northwestern part of Great Salt Lake; Uinta County, asphalt-saturated sandstone is exposed in Asphalt Ridge a few miles west and south of Vernal; prospected and some mined for use in paving the streets in Vernal. *See* Gilsonite, Nigrite, Ozokerite, Uintaite, and Wurtzilite.

Autunite. Kane County, 9 miles south of Pahreah.

Azurite (blue carbonate of copper). Occurs in Beaver County; Juab County, in mines of Tintic district; Summit County, in Park City mines.

Barite (heavy spar). Occurs in Juab County, as gangue mineral of Tintic district; Salt Lake County, Bingham and Alta.

Beaverite. Beaver County, Horn Silver mine, near Frisco.

Bentonite. Garfield County on the upper part of Crescent Creek, Henry Mountains.

Beryl. Tooele County, occurs about 35 miles southwest of Simpson Springs, Ibapah Mountain.

Bismuth. Beaver County, occurs sparingly as bismuthinite at Beaver; Boxelder County, near Lucin; Juab County, occurs in Tintic district with silver-lead ores; Salt Lake County, recovered from smelter bullion, Bingham Junction; Tooele County, has been found sparingly as bismuthinite and carbonate in Clifton district, in Deep Creek Mountains.

Bismutite. Generally occurs in the oxidized portions of bismuth deposits.

Bornite. Salt Lake County, secondary ore mined in Bingham district.

Brown iron ore (limonite). Iron County, occurs near Modena, containing silver, lead, and gold. Extensive deposits in Iron, Juab, Morgan, and Uinta counties; used as flux in lead smelting.

Calciovolborthite. Grand County, mined with carnotite at Richardson.

Carnotite. Emery County, is mined on the east flank of San Rafael Swell, 18 miles west of Greenriver, in Upper Jurassic (?) sandstone; occurs in Temple Rock on the southeast side of the Swell and along San Rafael River; Garfield County, on the east and southwest flanks of the Henry Mountains, particularly on Crescent and Trachyte creeks; Grand County, is mined near Richardson in sandstone, with calciovolborthite and copper minerals, and 22 miles southeast of Thompsons with calcium vanadate; occurs in numerous places in the La Sal Mountains, particularly on Pack Creek, where it is mined; San Juan County, of mineralogic importance only, in White Canyon 8 miles from Hite; many deposits in Dry, Big Indian, and Lisburne Valleys north of Monticello; Uinta County, small deposits in pre-Cambrian quartzite, on Red Creek, Browns Park, with copper minerals; Wayne County, near the north end of the Henry Mountains, of mineralogic importance only.

Cement material. Producing plants in Boxelder County at Bakers Spur, and Morgan County at Devils Slide. Cement rock and limestone from quarry in Parleys Canyon, used for Portland cement at Salt Lake City.

Cerargyrite (horn silver). In the ore of various mines, especially those in Beaver, Juab, Salt Lake, and Summit counties.

Cerussite (lead carbonate). Juab County, important ore of Tintic district; Salt Lake, Summit, Tooele, and Utah counties, abundant in many of the mines.

Chalcocite (copper glance). Salt Lake County, secondary ore at Bingham.

Chalcopyrite (copper pyrites). Beaver County, principal ore in Cactus mine; Juab County, primary ore mineral of Tintic district, gold bearing; Salt Lake County, with pyrite at Bingham, mined for copper, gold, and silver.

Chrysocolla (copper silicate). Juab County, found in abundance in Tintic district.

Cinnabar. Tooele County, occurs in ores in Mercur district; was formerly mined.

Clay (brick). Dug in Boxelder County, north of Brigham; Cache County, Logan, and Smithfield; Davis County, Bountiful, Kaysville, and Woods Cross; Emery County, Ferron; Iron County, Cedar City; Salt Lake County, Murray, Salt Lake, and West Jordan; San Juan County, Monticello; Sanpete County, 3 miles south of Manti; Sevier County, Richfield; Summit County, Coalville; Uinta County, Vernal; Utah County, Lehi Junction, Pleasant Grove, and elsewhere; Weber County, Harrisville and Roy.

Clay (fire). Dug in Salt Lake County, near Salt Lake and Fort Douglas; Utah County, Lehi Junction, and Pleasant Grove; Weber County, in small quantity at North Ogden.

Coal (bituminous and subbituminous). *Blacktail Mountain field.*—Wasatch County, occurs near Blacktail (Tabby) Mountain, in Mesaverde and Mancos formations; thoroughly prospected; very little mining done.

Book Cliffs field.—Includes portions of Carbon, Emery, Grand, and Sevier counties; Mesaverde formation; mined at Sunnyside, coked; Scofield, Castlegate, and Winterquarters, Carbon County.

Colob-Harmony field.—Garfield, Iron, Kane, and Washington counties; from Cedar City, Iron County, to Mount Carmel, Kane County, bituminous; mined near Kanarra, Cedar City, Coal Creek Canyon; locally called black lignite; coal in Upper Cretaceous deposits.

Emery coal field.—Emery County, occurs in Mancos shale south and east of Emery in Coal Cliffs; prospected and some mined for local use.

Henry Mountain coal field.—Garfield and Wayne counties, occurs west and northwest of Mount Ellen, Henry Mountains; prospected.

Sanpete County.—Wales mine, Wasatch bed (Eocene); Sterling coal (Upper Cretaceous) mined at Momson mine east of Sterling, bituminous.

Vernal field and Henrys Fork field.—Uinta County, bituminous coal mined in the Upper Cretaceous (Mancos shale) near Vernal.

Weber River or Coalville field.—Summit County, coal in Upper Cretaceous rocks of Benton age; mined at Wasatch and Dexter mines, Coalville, subbituminous.

Copper. *See* Azurite, Bornite, Chalcocite, Chalcopyrite, Chrysocolla, Covellite, Cuprite, Enargite, Malachite, Tenorite, and Tetrahedrite.

Covellite. Salt Lake County, in Bingham district.

Cosalite. Beaver County, Frisco district.

Cuprite (copper oxide). Juab County, occurs in mines of Tintic district.

Elaterite. *See* Wurtzilite.

Enargite. Juab County, abundant, original mineral of Tintic district.

Galena. Important ore of many mines in Beaver, Juab, Salt Lake, Summit, Tooele, and Utah counties; mined at Tintic, Bingham, Park City, and elsewhere.

Gilsonite. Uinta County, mined at Dragon and elsewhere. *See also* Uintaite.

Gold (lode). Predominant ore in Beaver County, Bradshaw and Newton districts; Box Elder County, Park Valley district; Grand County, Miners Basin; Iron County, Gold Springs and Stateline; Juab County, Spring Creek and Tintic; Piute County, Kimberley and Ohio; San Juan County, Blue Mountains; Tooele County, Mercur; Uinta County, Carbonate; Wasatch County, North Fork and Snake Creek.

Gold (placer). Small production from black sands in Garfield County, White Canyon district; Grand County, at Wilson Mesa; Iron County, at Sand Springs; Salt Lake County, in Bingham Canyon; San Juan County, Bluff; Uinta County, Green River.

Granite. Small quantities quarried in Box Elder County, at Willard; Salt Lake County, Draper; Utah County, Alpine City and Provo City; Weber County, Ogden.

Gypsum. Iron County, enormous deposits reported; Emery and Wayne counties, enormous deposits in Jurassic along margin of San Rafael Swell; Juab County, large deposits mined near Nephi and Levan; Millard County, vast deposits at White Mountains; Salt Lake County, in small quantities in fibrous and selenitic form; San Juan County, Monticello; Sevier County, Sigurd. Black gypsum found also in Grand County, between Grand River and La Sal Mountains; Kane County, near Kanab; Sanpete County, near Gunnison; Sevier County, near Richfield; Washington County, in eastern part of county; Wayne County, in South Washington.

Hematite (red iron ore). Iron and Washington counties, immense quantities in Iron Mountain district, has been mined at Iron City; Wasatch County, large deposits at the head of Duchesne River, in the Uinta Range, small quantity mined for flux.

Hübnerite. Tooele County, with scheelite in mines of Clifton district, Deep Creek, associated with copper, gold, silver, lead, and bismuth ores.

Infusorial earth. Beaver County, was formerly mined at Milford.

Iron. *See* Brown iron ore, Hematite, and Magnetite.

Lead. *See* Anglesite, Cerusite, Cosalite, and Galena.

Limestone (building). Quarried in Beaver County, at Beaver and Greenville; Carbon County, on Tie Fork of Soldier Creek, 7 miles northwest of Clearcreek; San Juan County, Grayson; Sanpete County, Ephriam; Utah County, Lehi and Provo.

Limestone (crushed stone). Quarried at Ogden and Salt Lake City.

Limestone (flux). Used in Salt Lake County, at Salt Lake City; Tooele County, at Topliff; Weber County, Hot Springs.

Limestone (lime). Burned in Beaver County, at Beaver; Iron County, Cedar City; Salt Lake County, Salt Lake; Sevier County, Richfield; Utah County, near Provo.

Limonite. *See* Brown iron ore.

Magnetite. Iron and Washington counties, large deposits with hematite in Iron Mountain district.

Malachite (green carbonate of copper). Occurs in Beaver County, Cactus mine; Juab County, in many Tintic mines; Summit County, Park City mines.

Manganese ore. Juab County, Tintic district, chiefly manganiferous silver ores; also near Joy.

Marble. Beaver County, quarried at Beaver City; occurs also in Juab, Salt Lake, Sanpete, Summit, Utah, and several other counties.

Molybdenite. Salt Lake County, occurs in canyon on south side of Little Cottonwood Canyon and elsewhere.

Monazite. Uinta County, occurs in black sands in Green River, Jensen district.

Natural gas. Salt Lake County, small quantity found in valley of Jordan River and in vicinity of Salt Lake City; has been exploited.

Nigrite. Utah County, occurs at Soldier Summit and vicinity; small quantity has been mined.

Niter (saltpeter). Iron County, several small beds near Parowan; Millard County, occurs near Fillmore.

Obsidian. Occurs in regions of Tertiary volcanic rocks; small quantities cut for gem purposes.

Opal. Beaver County, occurs near Milford.

Orpiment (yellow sulphide of arsenic). Garfield County, occurs in irregular seams in shale in Coyote Creek Valley; Tooele County, in good crystals in Mercur district; Salt Lake County, limited quantity in one silver mine in Bingham Canyon.

Ozokerite (mineral wax). Utah County, occurs at Soldier Summit and near Colton; small quantities have been mined.

Petroleum. San Juan County, 9 producing wells in San Juan field at close of 1911; Washington County, 6 producing wells in Virgin field.

Phosphate rock. Morgan County, occurs in Carboniferous limestone in upper canyon Weber River between Morgan and Devils Slide Station, little prospecting; Rich County, in Crawford Mountains near Randolph, mined and shipped, also at other points in Rich County; Salt Lake County, in foothills east of Salt Lake City; Weber County, in limestone in Shepherd Valley, 6 miles southeast of Huntsville, east of Beaver Creek, and near Ogden Canyon.

Platinum. Occurs sparingly in black sands in Garfield County, at Hite; also in Salt Lake County.

Plumbojarosite. Beaver County, Horn Silver, Hub, Moscow, Red Warrior, Harrington-Hickory mines and prospects.

Pyrite. Beaver County, principal ore of Cactus mine, Frisco district; Juab County, original mineral of Tintic district; Salt Lake County, massive and in grains disseminated through monzonite in Bingham district, mined for gold and silver.

Quicksilver. Piute County, mercury ores, onofrite and tiemannite have been mined 5 miles southeast of Marysvale. *See also* Cinnabar.

Realgar. Garfield County, occurs in irregular seams in shale in Coyote Creek Valley; Salt Lake County, in some mines of the Bingham district. Tooele County, in Mercur district.

Salt (brine). Produced in Juab County, at Nephi City; Millard County, Clear Lake; Salt Lake County, Saltair; Sanpete County, near Gunnison; Sevier County, Redmond; Weber County, Ogden and Whithie Junction.

Sand and gravel. Dug at Box Elder County, Brigham City and Pigeon; Salt Lake County, Salt Lake City and Sandy; Tooele County, Stockton; Utah County, Point Mountain.

Sandstone. Quarried in Grand County, at Moab; Iron County, Cedar City and near Buck Horn; Salt Lake County, Salt Lake City; Sanpete County, Manti; Summit County, Park City; Utah County, Colton and Thistle.

Scheelite. Tooele County, with hübnerite in mines of Clifton district, Deep Creek Mountains, associated with copper, gold, silver, lead, and bismuth ores.

Scorodite. Tooele County, occurs in Gold Hill mine, Clifton district.

Silver. Yield principally from lead-ore mines in following districts: Beaver County, Beaver Lake, North Star, Washington; Juab County, Fish Springs, West Tintic; Summit County, Park City; Tooele County, Ophir, Rush Valley, Willow Springs; Utah County, American Fork, Silver Lake, Santaquin. Predominant ore in several other districts. Little silver in copper ore of Cactus mine, Beaver County, and in copper at Bingham, Salt Lake County. *See also* Argentite and Cerargyrite.

Slate. Utah County, occurs 2 miles southeast of Provo.

Sphalerite (zinc blende). Mined with argentiferous lead ores of Summit County, in Park City district, and Salt Lake County, Bingham.

Stibnite (sulphide of antimony). Garfield County, occurs with antimony oxides at Coyote Creek; ore has been shipped.

Sulphur. Beaver County, mined at Sulphurdale; Emery County, occurs along San Rafael River in the San Rafael Swell, and on Cedar Mountain.

Tenorite. Salt Lake County, occurs as secondary ore at Bingham.

Tetrahedrite (gray copper ore). Salt Lake County, secondary ore at Bingham; Summit County, principal copper ore in silver mines at Park City.

Tiemmanite. Piute County, formerly mined near Marysvale.

Topaz. Juab County, occurs at Topaz Mountain, 8 miles northwest of Joy; has been cut for gems.

Travertine (Utah onyx). Deposits in Boxelder, Millard, and Utah counties; has been quarried and used in interior work.

Tufa. Beaver County, quarried near Beaver City.

Uintaite (gilsonite). Uinta County, Uinta Basin in eastern Utah, mined at Fort Duchesne, and in Bonanza and Cowboy claims, near Utah-Colorado line, on White River; many other small veins in Uinta County.

Uranium. Wayne County, uranium sulphate occurs in a fine-grained sandstone with copper carbonates near Fruita. *See also* Carnotite.

Uranospinite. Kane County, 9 miles south of Pahreah.

Vanadium. Emery County, calcium vanadate has been mined in a small way with carnotite in asphaltic sandstone in Wild Horse Canyon; Grand County, calcium vanadate has been mined with carnotite on claims 8 miles south of Thompson's, and 20 miles south of Cisco. *See also* Carnotite and Calciovolborthite.

Variscite (amatrice). Boxelder County, mined 5 miles north of Lucin; Tooele County, mined 14 miles south of Tooele, and occurs 2 miles from Mercur; Utah County, occurs in Clay Canyon, 1½ miles west of Fairfield.

Wood, silicified. Very abundant on San Rafael Swell and Henry Mountains.

Wulfenite (molybdate of lead). Salt Lake County, occurs in limestone with lead ores in Alta district, small quantity.

Wurtzilite (elaterite). Wasatch County, found in an area embracing about 100 square miles in region of Indian, Lake, Avintequin, and Sams canyons, little northeast of Grey Head Mountain and about 50 miles southwest of Fort Duchesne; 3 or 4 promising veins; mined and shipped from Sams and Avintequin canyons.

Wurtzite. Beaver County, Horn Silver mine, near Frisco.

VERMONT.

Arsenopyrite (mispickel). Brookfield, Stockbridge, Vershire, and Waterbury, with pyrite and chalcopyrite; not mined.

Asbestos. Mined in Lamoille County, at Eden; Orleans County, near Chrysotile and Lowell.

Braunite. Bennington, Brandon, Chittenden, and Plymouth, in small quantities; not mined.

Brown iron ore (brown hematite, limonite). Bennington County, Bennington, formerly dug to some extent; Rutland County, with manganese ores at Brandon and South Wallingford; Windsor County, Plymouth, was formerly mined in connection with ocher and kaolin.

Cement material. Limestone suitable for Portland cement in many counties; not used.

Chalcopyrite (copper pyrite). Orange County, has been mined at Corinth, in Ely mine at Copperfield, and Elizabeth mine at South Strafford.

Clay (brick). Pits in Caledonia County, at East Ryegate; Chittenden County, Champlain and Essex Junction; Rutland County, Rutland; Washington County, Waterbury; Windham County, Putney; Windsor County, Wilder.

Clay (fire). Rutland County, mined at Rutland.

Clay (kaolin). Addison County, deposit at Monkton, not mined; Bennington County, mined at Shaftsbury; Rutland County, mined at Forestdale.

Feldspar. Orange County, deposits at Corinth and Strafford, not worked; Windham County, deposits at Newfane and Saxtons River, not worked; Windsor County, quarried at Chester, deposit at Norwich not worked.

Flagstone. Windsor County, gneiss at Cavendish; small quarries in slate between Hartford and Rockingham, not working.

Galena. Lamoille County, in small vein in talcose slate at Morristown; Orange County, has been mined in quartz vein in talcose slate at Thetford; Rutland County, small occurrence at Chittenden; Windsor County, found at Bridgewater, Carter, and Plymouth; formerly mined at Carter.

Gold (placer). Windsor County, formerly mined to small extent at Plymouth. Found in very small quantities in many places.

Gold (lode). Formerly mined in small way in Bennington County, at Readsboro; and Windsor County, Bridgewater Center.

Granite. Caledonia County, Groton, Hardwick, Kirby (3 quarries), Newark, and South Ryegate (6 quarries); Essex County, was formerly quarried at Brunswick and Victory; Orange County, Williamstown (3 quarries), formerly quarried at Topsham and Randolph; Washington County, Barre (34 quarries), Calais (3 quarries), Graniteville, Websterville, and Woodbury (12 quarries); Windham County, West Dummerston (3 quarries); Windsor County, Windsor (2 quarries), Rochester, and Bethel (2 quarries).

Graphite. Has been found in Addison County, at Hancock; Chittenden County, Huntington; Franklin County, Swanton; Orange County, Newbury; Rutland County, Brandon and Pittsford; Windham County, Halifax; and Windsor County, Norwich.

Hematite. Chittenden County, Milton near Lake Champlain, formerly worked to slight extent; Windsor County, small deposit at Weathersfield.

Infusorial earth. Caledonia County, Peacham, and many other places; not mined.

Limestone. Quarried for building stone; Grand Isle County, Isle La Motte; quarried chiefly for lime: Addison County, Leicester Junction and New Haven; Chittenden County, Colchester; Franklin County, Highgate, Highgate Springs, St. Albans, and Swanton; Rutland County Brandon; Windsor County, Amsden.

Limonite. *See* Brown iron ore.

Magnetite. Orleans County, Troy, a titaniferous ore in small beds, formerly mined; Windsor County, Bridgeport and at Rochester, sparingly in chlorite slate.

Malachite (green carbonate of copper). Orange County copper mines; not mined.

Manganese ore. Reported in Addison County, Bristol and Monkton; Bennington County, from Bennington and Stamford; Chittenden County, Colchester; Orange County, Topsham; Orleans County, Irasburg and Coventry; Rutland County, Chittenden and Pittsford, near South Wallingford and Brandon, in Otter Creek Valley; Windsor County, Plymouth. Nowhere mined. *See* Psilomelane and Pyrolusite.

Marble. Quarried in Addison County, at Beldens Falls, Middlebury, Monkton, and Vergennes; Bennington County, Dorset and East Dorset; Chittenden County, Burlington; Franklin County, St. Albans and Swanton; Rutland County, Brandon, Danby, Fowler, Pittsford, Proctor, Rutland, and West Rutland; Washington County, Roxbury.

Marl. Caledonia County, deposits at Sutton, not worked. Abounds in most of towns bordering Lake Champlain, also in Orange and Windsor counties.

Mica (muscovite). Rutland County, at North Sherburne; Windsor County, at Chester, has not been mined.

Ocher. Bennington County, formerly mined at Bennington, occurs at North Dorset, not mined; Leicester County, formerly mined at Brandon.

Peat. Numerous localities, Champlain Valley and elsewhere; not utilized.

Psilomelane (black manganese). Rutland County, was formerly mined near South Wallingford and at Brandon.

Pyrite. Orange County, has been mined in Copperas Hill mine at Strafford, large deposit interstratified with mica schist, associated with chalcopyrite; also at Brookfield, Corinth, and Vershire; Rutland County, Cuttingsville.

Pyrolusite (manganese dioxide). Rutland County, was formerly mined near South Wallingford and at Brandon.

Pyrrhotite. Orange County, with copper ores of Ely mine, Copperfield, Elizabeth mine, South Strafford, and Union and Eureka mines.

Sand (building). Dug in Rutland County, Rutland, and at many other localities.

Sand (glass). Bennington County, East Dorset, disintegrated quartz rock once used for glass; Windsor County, Plymouth, associated with kaolin, not mined.

Sand (molding). Dug in Rutland County, Rutland; Windsor County, Springfield.

Sandstone. Quarried for building stone at Burlington, Chittenden County, and elsewhere.

Schist, mica. Formerly quarried at Halifax, Windham County. Abundant in many localities but quarried only as needed locally.

Serpentine (verde antique marble). Washington County, quarried at Roxbury. Deposits in Orleans County, at Troy, and Westfield; Windham County, Marlboro; Windsor County, Cavendish and Windsor.

Siderite (spathic iron ore). Windsor County, Plymouth, in talcose slate, with magnetite and pyrite; not mined.

Slate. Principal quarries in Rutland County, at Blissville, Brandon, Castleton, Fair Haven, Granville, Hydeville, North Poultney, Pawlet, Poultney, Wells, West Castleton, and West Pawlet; Washington County, Montpelier and Northfield.

Soapstone and talc. Quarried: Addison County, at East Granville; Lamoille County, Johnson; Washington County, Moretown; Windham County, Hammondsville and Windham; Windsor County, Cluster, Perkinsville, Rochester, Stockbridge and Weatherfield. Deposits not utilized: Orleans County, at Lowell; Washington County, Roxbury; Windham County, Newfane; and Windsor County, Bridgewater.

Sphalerite (zinc blende). Lamoille County, sparingly with galena; Orange County, small quantity mined with copper ores, occurs in lead mine, Thetford; Windsor County, at Norwich, sparingly with galena at Bridgewater, contains cadmium, not mined.

Talc. *See* Soapstone.

Trap rock. Occurs in dikes; scattered quarries only.

Umber. Rutland County, formerly obtained at Brandon.

Whetstone (scythestone). Orleans County, quartz-mica schist, quarried at Evansville; formerly quarried near Canada line, Lake Memphremagog, Fitchs Island quarry, honestones; Washington County, Northfield, talc schist, scythestones; Windsor County, Ludlow and Stockbridge, scythestones.

VIRGINIA.

Allanite. Amelia County, masses weighing several pounds in mica mines; Amherst County, iron allanite carrying nearly 17 per cent ceria in mica-free pegmatite with blue quartz, sipylite, and zircon at Massie mine on Little Friar Mountain; Bedford County, allanite with 33 per cent ceria near Thaxton; Page County, iron allanite, Owen prospect, 3 miles southeast of Marksville.

Alum. Small accumulations in caves or sheltered spots have been used.

Amethyst. *See* Quartz.

Apatite. Amelia County, with mica and beryl in mica mines; Nelson County, with nelsonite and rutile near Roseland.

Arsenic. Floyd County, refined from arsenopyrite mined at Brinton.

Arsenopyrite (arsenical pyrite). Buckingham County, associated with pyrite, in gold veins near Arvonia, Dillwyn, and elsewhere; Carroll County, southern copper lode; Culpeper County, 18 miles west of Fredericksburg, on Rapidan River; Fauquier County, near Morrisville; Floyd County, in mica-quartz schists 4 miles from Lick Fork, mined for arsenic at Brinton; Goochland County, associated with pyrite, in gold veins west of Caledonia and elsewhere; Grayson County, southern copper lode; Orange County, near Rapidan River and along narrow-gage railroad between Fredericksburg and Orange; Rockbridge County, with cassiterite in quartz veins in Irish Creek area; Spotsylvania County, in northwest corner; Stafford County, in western part.

Asbestos (amphibole). Albemarle County, in thin platy masses in the soapstone at Alberene; Amelia County, has been mined near Appomattox River, 7 miles north of Mattox station; Bedford County, 12 miles south of Bedford City; an asbestos mill was built at Bedford City some years ago; small production reported in 1911; Buckingham County, Anaconda (formerly Eldridges Mill), 5½ miles northwest of Dillwyn; Fauquier County, Barnets Mill; Floyd County, Bartons and Singers; Franklin County, was mined 2 miles east of Rocky Mount; Grayson County, near northern copper lode; on Little River below Hampton mine; Wythe County, lead and zinc mines, Painters Branch; also in Goochland, Pittsylvania, and Powhatan counties. None produced in 1910.

Azurite (blue carbonate of copper). Madison County, small quantities in prospects near Fishers Gap; Mecklenburg County, fine crystals filling small cavities in quartz and epidote at Pontiac mine, 8 miles north of Virgilina; Page County, mines and prospects southeast of Luray near Ida; Rockingham County, mines and prospects near High Knob southeast of Elkton, small quantities; Warren County, near Bentonville, Front Royal, and Linden; has been mined at Bentonville.

Barite (heavy spar). Bedford County, near Thaxton, between Bedford and Roanoke, was mined and shipped; Campbell County, occurs east of Evington, near Otter River Station, and at Leesville; Louisa County, in schists near

Mechanicsville, has been mined; Pittsylvania County, occurs at Toshes, near Motleys and Hurt; Prince William County, occurs with red shales 4 miles east of Catlett Station; Russell County, extensive deposits near Honaker and Lebanon, mined and shipped; Smyth County, near Marion, was extensively mined and shipped; Tazewell County, near North Tazewell and Richlands, not used; Washington County, near Glade Spring and Saltville Branch of Norfolk & Western Railway, in clays; Wythe County, with metallic ores in zinc and iron mines near Ivanhoe and elsewhere in southern part of county.

Bauxite. Botetourt County, at Old Houston iron and manganese mines 2 miles east of Troutville.

Beryl. Amelia County, in mica mines near Amelia; Henry County, in pegmatite near Axton; Rockbridge County, with cassiterite in Irish Creek area.

Bornite (purple copper ore). Amherst County, with actinolite in old Folly mine, 4 miles south of Amherst; Charlotte County, in quartz near Keysville, has been mined; Grayson County, in schist in southwestern part of county, prospects; Greene County, near Elkton; Halifax County, in quartz at Virgilina copper mines; Loudoun County, has been mined near Leesburg; Madison County, one of primary copper minerals near Fishers Gap, prospects; Page County, near Ida, southeast of Luray, one of original copper minerals; Rappahannock County, Manassas Gap copper mine near Front Royal; Rockingham County, disseminated ore in mines and prospects near High Knob southeast of Elkton; Warren County, has been mined near Bentonville.

Brown iron ore. *See* Mountain brown ore, Oriskany brown ore, Valley brown ore.

Calamine (silicate of zinc). Pulaski County, oxidized ore of Delton mines near Delton, has been mined; Russell County, principal ore of prospects on Copper Creek, 10 miles north of Castlewood; Wythe County, secondary ore of lead and zinc mines at Austinville.

Coke (natural). Chesterfield County, Chesterfield (Triassic) coal basin.

Cassiterite (tin ore). Reported in Clarke County, at Capon Springs; Nelson County, at Nellysford; Rockbridge County, in Irish Creek area.

Cement (natural). Rockbridge County, Cambrian limestone used in natural cement at Glasgow and near Balcony Falls; mills also in Botetourt County.

Cement (Portland). Augusta County, limestone and shale abundant at several places; plant at Fordwich; Clarke County, limestone in vicinity of Wadesville; Frederick County, limestone near Winchester and Middletown; Giles County, limestone and shale in Copper Creek area and near Lurich; Lee County, limestone and shale abundant near Wallen Ridge and Cumberland Mountain, also at Big Stone Gap and Pennington Gap; Norfolk County, plant at Norfolk using shell marl from Smithville and Chuckatuck; Rockingham County, limestone and shale exposed at several places in vicinity of Harrisonburg; Russell County, along west slope of Clinch Mountain; Scott County, Copper Creek, Clinchport, and Gate City; Shenandoah County, abundant in vicinity of Strasburg and near Woodstock; Smyth County, along western foothills of Walker Mountain; Tazewell County, between Cedar Bluff and Tiptop station, through Clinch River Valley and elsewhere; Warren County, shales and limestone at Riverton and vicinity, extensively quarried; Washington County, near Walker Mountain, Bristol, and Abingdon. Calcareous marls and clays of the Coastal Plain are used for the manufacture of Portland cement at Norfolk.

Cerussite (lead carbonate). Wythe County, occurs in residual clays derived from limestone and on galena at Austinville.

Chalcocite (copper glance). Carroll County, copper lodes west and northwest of Hillsville; Charlotte County, in quartz near Keysville, has been mined; Floyd County, Toncray mine, with magnetite and pyrite; Halifax County, in quartz at Virgilina copper mines; Smyth County, Mount Airy; Wythe County, near Max Meadows.

Chalcopyrite (copper pyrite). Albemarle County, was mined for gold near Stony Point; Botetourt County, small quantity near Bonsack station; Buckingham County, near Dillwyn, Arvonia, and elsewhere; Carroll County, in Gardner and Goad mines in northeastern part of county; Culpeper County, has been mined for gold 18 miles west of Fredericksburg on Rapidan River; Fairfax County, has been mined near Herndon; Floyd County, large quantity with pyrrhotite near Floyd, has been mined; Franklin County, small quantities with pyrrhotite at Howell mine near Rocky Mount; Goochland County, mined for gold 2 miles west of Caledonia; Grayson County, near Troutdale; Greene County, small quantity near Stanardsville and Elkton; Loudoun County, has been mined at Guilford; Louisa County, has been mined, frequent in small quantities of pyrite in Mineral City mines; Madison County, one of the original copper minerals in prospects near Fishers Gap; Orange County, near Rapidan River and between Fredericksburg and Orange, carries gold; Page County, mines and prospects southeast of Luray near Ida; Patrick County, carrying small quantity of gold along western boundary in the Blue Ridge, in the vicinity of Vesta and elsewhere; Prince William County, mined with pyrite in considerable quantities at Cabin Branch mine near Dumfries, matte produced; Rockingham County, at mines and prospects near High Knob southeast of Elkton; Warren County, near Linden, has been mined.

Chromite (chromic iron ore). Fairfax County, Dranesville, in serpentine near the Potomac.

Chrysocolla. Warren County, has been mined near Front Royal, in epidote rock.

Clay (brick). Clay dug and brick made: Alexandria County, around Alexandria, Arlington, Addison, Riverside; Caroline County, near Milford; Charles City County, Sturgeon Point, Oldfield, about 4 miles south of Sturgeon Point; Chesterfield County, Bermuda Hundred, much clay exposed in this general vicinity, Manchester, Ettricks; Dinwiddie County, near Petersburg; Elizabeth City County, Hampton; Essex County, along Rappahannock River, near Layton, at Occupacia; Greenesville County, around Belfield, adjoining Emporia; Henrico County, Rocketts (suburb of Richmond), Fort Lee; Fulton, near Stagg's mill on Williamsburg road, near Curles Neck, near Cotman post office; King George County, along Rappahannock River near Wilmot; Nansemond County, general vicinity of Suffolk, along Nansemond River; Prince George County, Broadway area along Appomattox River below Petersburg, in bluff along James River near City Point; Princess Anne County, Princess Anne Road near Godfrey Avenue; Spotsylvania County, near Fredericksburg; Warwick County, Morrison. Brick is made from the residual clays at one or more principal towns in most of the Piedmont counties.

Clay (fire). Mined and used in Botetourt County, at Catawba Furnace; in Appomattox, Buckingham, and Cumberland counties; Chesterfield County, at Bon Air; Montgomery County, near Christiansburg; Orange County, Madison Run; Powhatan County, Clayville; Rockbridge County, Buena Vista; Wythe County, under coal seams in southwest angle of State Lick Mountain.

Clay (kaolin). Henry County, mined at Oak Level; reported from Amelia, Amherst, Nelson, and Nottoway counties; Augusta County, Kaolin or Sherando station; from crystalline area of Cumberland and Prince Enward counties; Fauquier County, near Warrenton; Henrico County, at Bon Air, 9 miles from Richmond; Smyth County, near Rye Valley; Wythe County, near Wytheville.

Clay (pottery). Miocene clays suited for pottery occur in Hanover, Henrico, King William, and other counties.

Coal (anthracite). Frederick County, small field of semianthracite undeveloped; Montgomery and Pulaski counties, small basin developed.

Coal (bituminous). Produced more than 6½ million tons in 1911. Field in southwestern part of State includes Buchanan, Dickenson, Lee, Russell, Scott, Tazewell, and Wise counties; coal is of high quality, and there are several thick beds. Buchanan County, large quantity of bituminous coal, undeveloped for lack of railroad; Dickenson County, considerable area, several beds of fine bituminous coal, prospected, not mined for lack of railroad; Lee County, north of Pennington Gap, several mines; Russell County, Dante, Dumps Creek, large mines; Tazewell County, Pocahontas, Big Creek, large mines; Wise County, Toms Creek, Norton, and north of Bigstone Gap, several large mines. Farmville area, including Cumberland, Buckingham, and Prince Edward counties; thin seams. Richmond area, Chesterfield, Goochland, and Henrico counties; Triassic coal, mined at Midlothian and at Winterpock, Chesterfield County; Gayton, Henrico County, bed 4 feet 8 inches, shipped. Pocket coal district between Cumberland and Little Black Mountains north of Pennington Gap, of Pottsville (early Pennsylvanian) age; 12 workable beds; mined from small banks for local supply.

Columbite. Amelia County, with microlite in Amelia mica mines.

Copper (native). In small quantities at many localities along Blue Ridge region; Carroll County, native copper lode near Hillsville; Floyd County, Toncray mine; Greene County, near Stanardsville and Elkton; Halifax County, small quantity in Virgilina copper mines; Madison County, secondary ore at Fishers Gap, prospects; Page County, small quantities in mines and prospects southeast of Luray, near Ida; Rappahannock County, near Front Royal, has been mined; Rockingham County, at mines near High Knob, 7 miles southeast of Elkton; Warren County, near Linden, with cuprite and melaconite.

Copper minerals. *See* Azurite, Bornite, Chalcocite, Chalcopyrite, Cuprite, Malachite, and Melaconite.

Corundum. Patrick County, near Stuart, in mica schist on knob of Bull Mountain.

Cuprite (red oxide of copper). Greene County, near Stanardsville and Elkton; Halifax County, as alterations of original sulphides in Virgilina copper mines; Madison County, important ore of mines near Fishers Gap; Page County, at mines and prospects southeast of Luray near Ida; Rockingham County, near High Knob, 7 miles southeast of Elkton; Warren County, near Linden and Bentonville.

Diabase. Excellent quality widely distributed through the crystalline area and through several of the middle Valley counties west of the Blue Ridge; quarried in Fauquier County, near Catlett; Loudon County, near Goose Creek 3 miles from Leesburg.

Diamond. Chesterfield County, found at Manchester in 1855.

Diorite. Less abundant than diabase; occurs penetrating crystalline rocks east of Blue Ridge; quarried only near Annandale and Falls Church, Fairfax County.

Dufrenite (iron phosphate). Rockbridge County, South Mountain, 10 miles east of Lexington.

Emery. Pittsylvania County, with magnetite or hematite near Whittles.

Feldspar. Abundant, but few mines; Amelia County, was mined as accessory mineral to mica near Amelia Courthouse, and at Jetersville; Amazon stone variety found in Rutherford mine near Amelia Courthouse. Bedford County, was mined about 1 mile south of Bells on Otter River; Prince Edward County, mined near Prospect.

Fergusonite. Amelia County, in mica mines at Amelia Courthouse.

Flagstone. Buckingham County, slate was quarried on Hunts Creek.

Fluorspar. Albemarle County, gangue mineral at Faber lead and zinc mine, near Fabers, Nelson County; Rockbridge County, Irish Creek; Russell County, with barite in mines near Gardner and Honaker; Shenandoah County, near Woodstock; Smyth County, with lead and zinc in prospects in Rye Valley.

Fluorspar (chlorophane). Amelia County, in pegmatite at Amelia mica mines.

Gabbro. Limited to crystalline area of Blue Ridge; found in Amherst County, near Lynchburg; and in northwest corner of Floyd County.

Galena. Albemarle County, principal mineral in fluorspar lenses near Faber, argentiferous; Bedford County, disseminated through barite near Thaxton; Bland County, has been mined near Sharon, also in Garden and Flat Top Mountains; Buckingham County, near Arvonia, Dillwyn, and elsewhere, has been mined for gold; with copper ore near New Canton; Culpeper County, 18 miles west of Fredericksburg on Rapidan River, has been mined for gold; Fauquier County, near Morrisville 8 miles east of Bealeton, has been mined for gold; Floyd County, on west side Blue Ridge along Brush and Laurel Creeks, mined for gold; Goochland County, mined for gold 2 miles west of Caledonia, and elsewhere; Halifax County, in Virgilina copper district; Louisa County, frequent in small quantities with pyrite near Mineral City; Montgomery County, on west side Blue Ridge along Brush and Laurel creeks, mined for gold; Orange County, near Rapidan River and along railroad between Fredericksburg and Orange; Prince William County, occasionally in pyrite in Cabin Branch mine near Dumfries; Pulaski County, New River, near mouth of Reed Island Creek, with other lead and zinc minerals, Tract Mountain, and Big Walker Mountain; Russell County, on Copper Creek 7 miles south of Castlewood, has been mined; Smyth County, along south fork of Holston River in Rye valley, has been mined; Spotsylvania County in northwest corner of county, near Rappahannock River, and elsewhere, has been mined for gold; Wythe County, in association with sphalerite in zinc mines at Austinville.

Garnet (spessartite). Amelia County, gem hyacinth found in pegmatite in mica mines near Amelia.

Gneiss. Alexandria and Fairfax counties, extensively quarried along Potomac River; Amherst County, quarries on north side of James River; Bedford County, exposed along Norfolk & Western Railway at Bellevue; Campbell County, along streams, local use; Fluvanna County, has been quarried at Columbia; Pittsylvania County, has been quarried near Chatham on Cherrystone Creek.

Gold. In an auriferous belt from Potomac River to Halifax County 200 miles long and 15 to 25 miles wide, gold-bearing quartz veins and lenses in crystalline rocks, many mines and prospects opened, principally in Buckingham, Culpeper, Fauquier, Fluvanna, Louisa, Orange, Spotsylvania, and Stafford counties; Culpeper County, several localities in eastern part, also Culpeper gold mine; Fauquier County, has been mined in Franklin, Liberty, and other mines; Fluvanna County, Snead mine; Goochland and Fluvanna counties, Tellurium gold mine; Halifax County, in Virgilina copper district; Louisa County mines; Orange County, Chicago and Virginia mine; Spotsylvania County, Rappahannock mine, Randolph mine, Whitehall mines, Pocahontas mine at Andrews; Stafford County, Eagle mine.

Gold (placer). Has been mined in Buckingham County, in vicinity of Turpins Creek; Floyd and Montgomery counties, along Brush and Laurel creeks on western side of Blue Ridge; Goochland County, near Lantana; Louisa County, Tinder Flats; Spotsylvania County, along Pigeon Run; Stafford County, western part near Rappahannock River.

Granite. Production valued at more than one-half million dollars in 1910, largely for ballast and concrete. Principal producing areas are Fredericksburg, Petersburg, and Richmond. Quarries in Alexandria County, on bank of

Potomac River; Bedford County, Clevilas Tunnel; Campbell County, several quarries at Lynchburg; Chesterfield County, near Granite and Manchester; Fairfax County, quarried near Falls Church and Annandale; Goochland County, several quarries at Boscobel, Lee, and Lassiter; Greenville County, Emporia; Henrico County, several large quarries near Richmond; Lunenburg County, was quarried for crushed stone near Kenbridge; Nottoway County, for ballast near Jennings; Page County, near Luray; Prince Edward County, Farmville; Prince William County, Occoquan; Roanoke County, Roanoke; Spotsylvania County, large quarry 3 miles northwest of Fredericksburg. Granite is quarried in small way at other places, and occurs undeveloped and widely distributed in mountain district of Loudoun County, in Blue Ridge area and crystalline area eastward to the "fall line."

Graphite. Albemarle County, between Free Union and Boonsville, near Buck Mountain, blocks weighing several hundred pounds have been obtained; prospected but no production; occurs also at Charlottesville. Occurrences noted also in Amelia, Buckingham, Charlotte, Loudoun, Nelson, Orange, and Powhatan counties.

Gypsum. Mined in Smyth County, at Chatham Hill, North Holston, and Saltville; Washington County, Plasterco.

Halite. *See* Salt.

Hematite (specular). Occurs in workable quantity along Blue Ridge in Bedford, Botetourt, and Roanoke counties: Bedford County, Ironville and Dewey mines, near Montvale; Botetourt County, Arcadia and Wood mines, about 4 miles southeast of Buchanan; Lemon, Grubb-Specular, and Edith mines, about 3 miles northwest of Blue Ridge Springs; Roanoke County, Griffin-Specular mine 5 miles south of Roanoke.

Hematite (fossil ore). Occurs in workable quantity in Alleghany, Lee, and Wise counties; Alleghany County, has been mined on southeast slope of Horse Mountain, 3 miles southeast of Low Moor, and in bluff northeast of Jackson River at Iron Gate; Lee County, southwest of Pennington Gap along Poor Valley Ridge, includes Pennington, Lavine, Ben Hur, Truro, Noes Siding, Grabill, Boones Path, and Ewing mines; Wise County, south of Big Stone Gap, on Wallen Ridge, and in Powell Valley, fossil ore is mined at Yeary, Irondale, Keystone, and Oreton mines.

Ilmenite. Nelson County, with white apatite in dikelike masses (nelsonite) near Roseland; Roanoke County, with apatite near Roanoke.

Infusorial earth. Has been mined at Wilmont, King George County. An extensive deposit traceable from Herring Bay, Md., on the Chesapeake, to Petersburg, Va.; exposed along numerous streams near Richmond and Petersburg.

Kaolin. Amelia County, derived from decay of feldspar at Pinchback mine, shipped for pottery; Henry County, mined and shipped at Oaklevel; Nelson County, near Roseland; similar occurrences in other counties of the Piedmont province.

Lead. *See* Cerusite, Galena, and Massicot.

Limestone. Abundant west of the Blue Ridge; quarried in many localities from Frederick County to Wise County; also in Piedmont counties.

Limestone (building). Quarried in Botetourt County, at Compton Bridge; Loudoun County, Leesburg; Roanoke County, Roanoke; Washington County, Abingdon; Wythe County, small quantity at Wytheville.

Limestone (crushed stone). Quarried: Botetourt County, at Eagle Rock, Indian Rock, and Springwood; Campbell County, Lynchburg; Loudoun County, Leesburg; Roanoke County, Roanoke; Washington County, Abingdon.

Limestone (flux). Quarried: Alleghany County, at Longdale, Low Moor, and Clifton Forge district; Botetourt County, Buchanan, Eagle Rock, and elsewhere;

Pulaski County, Ardway; Rockbridge County, Bells Valley and Glasgow; Wise County, Big Stone Gap; Wythe County, Ivanhoe.

Limestone (hydraulic). Orange County, has been quarried at Madison Run; Rockbridge County, Balcony Falls on James River (a gray magnesian stone, noted "Balcony Falls cement").

Limestone (lime). Quarried: Augusta County, at Staunton; Botetourt County, Eagle Rock and Indian Rock; Frederick County, Stephen City and Winchester; Giles County, Ripplemead; Loudoun County, Lucketts and Leesburg; Montgomery County, Blacksburg and Christiansburg; Rockbridge County, Glasgow and Lexington; Rockingham County, Linville; Shenandoah County, Oranda and Strasburg; Warren County, Limeton and Riverton.

Limonite. *See* Mountain brown ore, Valley brown ore, Oriskany brown ore.

Magnetite. Principal deposits in Giles County, near Big Stony Junction; and Washington County, Abington; smaller deposits in Giles County, near Ripplemead; Louisa County, Mineral City; Wythe County, Wytheville; in many of the Piedmont counties, and has been mined in Franklin County, at Rocky Mount; and Pittsylvania County, at Pittsville.

Malachite. Buckingham County, with cupriferous pyrite in copper mine near Anaconda; Charlotte County, has been mined with chalcocite and bornite near Keysville; Halifax County, as alteration of original sulphides in Virgilina copper mines; Madison County, small quantity in Milans Gap prospects; Page County, has been mined southeast of Luray near Ida; Rappahannock County, has been mined near Front Royal; and Warren County, near Linden. Occurs in small quantity in many other places.

Manganese. *See* Psilomelane, Pyrolusite, and Wad.

Marble. Little or no marble has been produced in several years; quarried formerly to small extent in Rockingham County. Good quality of marble is reported, undeveloped in Albemarle County, west of Scottsville on Buck Island, and on Limestone and Meechum creeks; Botetourt County, about three-fourths mile southeast of Buchanan; Campbell County, a few miles from Lynchburg; Culpeper County, on Rapidan River near mouth of Summerduck Run and on Mountain Run; Fauquier County, on Rappahannock River, near Marsh Run; Giles County, near base of Angels Red Mountain and near Chapmans Ferry; Loudoun County, Taylortown and in vicinity of Goose Creek; Montgomery County, considerable quantity of black marble near Blacksburg; Nelson County, near mouth of Tye River; Orange County, between Gordonsville and Orange; Page County, on east side of Massanutten Mountain; Rockbridge County, 5 miles from Lexington; Scott County, near Gate City and in valley portion of county; Shenandoah County, near New Market and Woodstock.

Marble. *See* Onyx marble.

Marl (calcareous). Widely distributed in nearly all counties of tidewater region; also in many valley counties on west side of Blue Ridge; formerly of limited use as flux. Marl of the Coastal Plain has been used in manufacture of Portland cement.

Marl (greensand). Limited largely to inner margin of Coastal Plain region; exposed along Potomac, Rappahannock, Pamunkey, and James rivers and on interstream areas; used as fertilizer; has been worked at several places, especially on James and Pamunkey rivers; carries a small variable per cent of phosphoric acid; of little value as source of phosphate.

Massicot (lead ocher). Wythe County, Austin mines, in small quantities with galena and other lead ores.

Melaconite (black oxide of copper). Carroll County, in upper portions of copper lodes; also Floyd and Grayson counties; Warren County, has been mined at Linden.

Mica (muscovite). Has been prospected or mined: Amelia County, at Amelia and Jetersville; Bedford County, near New London; Goochland County, near Goochland; Hanover County, near Hewlett; Henry County, at Ridgeway; Pittsylvania County, south of Chatham; has been observed in several other counties; principal production from Amelia County.

Microlite. Amelia County, Amelia mica mines, fine brilliant yellow to red gem stone.

Millstone (burrstone). Montgomery County, Prices Fork, 5 miles southwest of Blacksburg, siliceous conglomerate quarried on Brush Mountain.

Monazite. Amelia County, fine specimens with microlite, in mica mines near Amelia; also found as sand in stream gravels.

Moonstone. Amelia County, occurs in mines at Amelia, some fine gems have been cut; Hanover County, found near Hewlett.

Mountain brown ore. Occurs in two belts, one extending along west slope of Blue Ridge from Front Royal, Warren County, to 10 miles south of Roanoke, Roanoke County; the other belt extends along the east side of the New River-Cripple Creek district, Pulaski County, and along and near to the Wythe-Carroll county boundary. Associated with Cambrian quartzite. Principal groups of mines: Page County, at Shenandoah; Rockingham County, Grottoes; Rockbridge County, Vesuvius and Buena Vista; Roanoke County, Roanoke; brown ore also mined near Pittsville, Pittsylvania County. Gossan ore of the sulphide deposits of crystalline area formed the basis of the first iron industry in the South.

Nelsonite. Prospected: Nelson County, near Roseland and Bryant; and Roanoke County, near Vinton.

Nickel. Reported in pyrrhotite from several localities in Piedmont region, especially in Floyd-Carroll-Grayson plateau in southwest Virginia and in Amherst County, near Lynchburg. Principal work done on Lick Fork, in Floyd County, 7 miles southeast of Shawsville.

Niter. In numerous caves in Shenandoah limestone in the valley on west side of Blue Ridge. Has been procured for local use.

Ocher. Has been mined: Bedford County, near Bedford City; Chesterfield County, near Bermuda Hundred, on Appomattox River; Loudoun County, in Little Catoctin Mountain, near Leesburg; Page County, Stanleyton, near Marksville; Rockingham County, near Keezletown and near west base of Massanutten Mountain, also along Naked Creek, 5 miles southeast of Shenandoah station; Warren County, excellent grade umber half mile east Shenandoah Railway, mined and shipped.

Onyx marble. Stalactitic and stalagmitic deposits on walls and floors of caves in Valley region; Luray, Page County, largest deposit.

Oriskany brown ore. Deposits occur locally in western portion of Appalachian belt from Maryland to southwestern Virginia. Principal mines in Alleghany County, near Longdale, Covington, Lowmoor, and Potts Creek. Other mines are: Augusta County, Buffalo Gap and Ferrol mines; Botetourt County, near Glen Wilton, Dagger Springs, and Oriskany; Pulaski County, Pulaski; and Wythe County, Max Meadows.

Phosphate. Alleghany County, phosphate nodules occur at base of Devonian black shale, near Clifton Forge, extent unknown. *See also* Marl and Nelsonite.

Psilomelane (manganese ore). Augusta County, Crimora, Lyndhurst, and Vesuvius mines; Botetourt County, Houston mines near Troutville; Campbell County, near Mount Athos and Evington; Nelson County, has been mined with pyrolusite near Warminster; Page County, Dry Run mine near Compton, also Eureka mine near Stanleyton, shipped; Rockingham County, several mines near Elkton; Smyth County, Umbarger mine near Sugar Grove and Currin Valley mine near Attoway.

Pyrite. Botetourt County, prospects near Bonsack station; Buckingham County, near Arvonia, Dillwyn, and elsewhere, has been mined for gold; Culpeper County, 18 miles west of Fredericksburg on Rapidan River, has been mined for gold; Dinwiddie County, near Pools Siding; Fauquier County, has been mined for gold near Morrisville; Goochland County, mined for gold 2 miles west of Caledonia and elsewhere; Louisa County, mined extensively for sulphuric acid at Mineral City; Montgomery and Floyd counties, on west side of Blue Ridge along Brush and Laurel creeks, gold-bearing; Orange County, near Rapidan River and along and north of narrow-gage railroad between Fredericksburg and Orange, gold-bearing; Prince William County, large deposit near Dumfries; Rockbridge County, with cassiterite in quartz veins in Irish Creek area; Spotsylvania County, in northwest corner and elsewhere, near Rappahannock River, was mined for gold; Stafford County, in western part near Rappahannock River, was mined at Garrisonville for gold. About one-half the production of the United States comes from Louisa and Prince William counties.

Pyrolusite (black oxide of manganese). Amherst County, scattered through clay and as replacements in granite at Stapleton, has been mined; Augusta County, in Lower Cambrian quartzite at Crimora mine near Crimora Station; Botetourt County, in manganiferous clay at Houston mines near Troutville; Campbell County, high grade in nodular masses and as replacements in granite at Mount Athos, Evington, Otter River, and Clarion (Lynch), mined near Evington, Mount Athos, and Otter River; Frederick County, in limestone at Paddy Mills mine in southwest corner of county; Nelson County, has been mined at Warminster and Midway Mills; Page County, Eureka mine near Stanleyton; Rockbridge County, Midvale; Shenandoah County, in sandstone at Powells Fort, has been mined at Baltimore and Philadelphia mines; Smyth County, in psilomelane at Umbarger mine near Sugar Grove and filling cavities in limonite at Currin Valley mine; Warren County, in limonite deposits associated with quartzite at Happy Creek mine near Front Royal; Wythe County, has been mined near Wytheville.

Pyrrhotite (magnetic pyrites). Largest occurrence is a lode varying in width up to 100 feet and extending 20 miles from Floyd County, through Carroll Mountains, Grayson County. Carroll County, mined for sulphuric acid between Chestnut Creek and New River near Sylvatus; Grayson County, in Carroll Mountains; Fauquier County, occurs near Broad Run; Floyd County, in mica schist 8 miles southeast of Floyd, also has been mined on Lick Fork in northern part of county, nickeliferous; Franklin County, in mica schist at Howell mine near Rocky Mount; Louisa County, with pyrite in mines near Mineral City; Prince William County, small quantity with pyrite in Cabin Branch mine near Dumfries.

Quartz (amethyst). Amherst County, has been mined 2½ miles northeast of Lowesville; Campbell County, good specimens found near Brookneal; Charlotte County, good specimens 2 miles west and 4 miles south of Charlotte.

Quartz (gem). Fairfax County, milky-white chalcedony, greenish-colored, colorless, and smoky quartz, near Fairfax; gems cut.

Quartzite. Found at various points along James River between Scottsville and Lynchburg, in Albemarle, Appomattox, Bedford, Buckingham, Campbell, Fluvanna, and Nelson counties. Quarries at several places formerly worked for building stone.

Road metal. *See* Gabbro, Gneiss, Granite, Limestone, Syenite, and Trap rock.

Rutile. Goochland County, mined near Peers; Hanover County, mined at Gouldin, in pegmatite dikes, in residual soil, and in gravels; Nelson County, occurs in large deposits of excellent quality, 5 miles northwest of Arrington on the Southern Railway, and in pegmatite and nelsonite dikes near Roseland

Salt (brine). Smyth County, pumped at Saltville, for manufacture of alkali and caustic soda. Formerly used for manufacture of salt; no salt made for some years.

Salt (rock). Occurs in large quantity with gypsum from Plasterco, Washington County, to within 3 miles of Chatham Hill, Smyth County; not mined.

Sand (building). Widely distributed, considerable quantity along streams; mined: Caroline County, at Massaponax; Pulaski County, Delton; Rockingham County, North River; Shenandoah County, Edinburg; Spotsylvania County, Fredericksburg; and other places.

Sand (glass). Fine white sand of suitable quality is found along eastern edge of Middle Valley region; Amherst County, Stapleton Mills; Augusta County, near Greenville; Rockbridge County, Balcony Falls, along west base of Blue Ridge; Roanoke County, Catawba Mountain, 9 miles northwest of Salem. Worked only at Salem locality.

Sand (molding). Has been found chiefly in vicinity of Fredericksburg, Petersburg, and Richmond. Is dug on Cowardin place at Richmond.

Sandstone. Lower Cambrian sandstone quarried along Chesapeake & Ohio Railway, Augusta County, for crushed stone. Silurian sandstone extends along Great Valley, fine to coarse, suitable for constructional work. Mississippian sandstone found in Augusta, Bland, Botetourt, Craig, Frederick, Montgomery, Pulaski, Roanoke, Rockingham, Shenandoah, Smyth, and Wythe counties; quarried at Pulaski, Pulaski County, for building material. Pennsylvanian sandstone found in Buchanan, Dickenson, Lee, Russell, Scott, Tazewell, and Wise counties; quarried for local building stone. Sandstone of the Newark group distributed in seven areas east of Blue Ridge, few quarries, good stone; quarried near Warrenton, Fauquier County, and in vicinity of Manassas, Prince William County. Cretaceous sandstone found near Fredericksburg on Rappahannock River, Spotsylvania County, and at several points in Brunswick, Chesterfield, and Greensville counties; has been quarried in vicinity of Aquia Creek and on Rappahannock near Fredericksburg, Spotsylvania County.

Schist (mica). Common in Piedmont region; quarried: Campbell County, at Altavista, for ballast; Franklin County, near Rocky Mount, for flagging.

Siderite. Washington County, with magnetite in limestone near Abingdon.

Silver. Halifax County, in copper ores of the Virgilina district; Louisa County, in pyrite mines near Mineral City.

Sipylite (niobate of erbium). Amherst County, adherent to magnetite occurs sparingly on northwest slope of Little Friar Mountain.

Slate. Quarried: Albemarle County, at Esmont; Amherst County, Snowden; Buckingham County, Arvonia; Fauquier County, has been quarried near White Sulphur Springs, 6 miles south of Warrenton; undeveloped beds in Craig, Prince William, and Stafford counties.

Smithsonite (zinc carbonate). Albemarle County, in lead-zinc mine near Faber; Pulaski County, oxidized ore of Delton mines near Delton, has been mined; Russell County, with calamine in prospects 10 miles north of Castlewood; Wythe County, secondary mineral of lead and zinc mines at Austinville.

Soapstone. Production much larger than that of any other State. Widely distributed in older crystalline rocks of Piedmont region east of Blue Ridge; Albemarle and Nelson counties, extensively quarried near Green, Hawkins, Findley, Ball, and Appleberry mountains. Has been quarried: Amelia County, at head of Walnut Creek; Campbell County, on Otter River; Charlotte County, near Cullen; Fairfax County, Annandale, near Clifton Station, Falls Church, and Tenley; Franklin County, Rocky Mount. Good stone undeveloped at many other localities.

Spessartite (garnet). Amelia County, fine gems cut from mines at Amelia.

Sphalerite (zinc blende). Albemarle County, common in fluorspar-quartz lenses near Faber; Bedford County, occasionally found in barite near Thaxton; Botetourt County, has been mined near Bonsack station; Buckingham County, has been mined for gold near Arvonia, Dillwyn, and elsewhere; Culpeper County, has been mined for gold 18 miles west of Fredericksburg on Rapidan River; Fauquier County, has been mined for gold near Morrisville; Goochland County, mined for gold 2 miles west of Caledonia and elsewhere; Halifax County, in Virgilina copper district; Louisa County, frequent in small quantities of pyrite in mines near Mineral City; Orange County, near Rapidan River and along and north of narrow-gage railroad between Fredericksburg and Orange; Prince William County, occasionally with pyrite in Cabin Branch mine near Dumfries; Pulaski County, prospected in unaltered limestone in bed of New River; Russell County, has been mined in Copper Creek 7 miles south of Castlewood; Smyth County, has been mined with galena along South Fork of Holston River in Rye Valley; Spotsylvania County, has been mined for gold near Rappahannock River in northwest corner of county; Stafford County, has been mined for gold in western part of county, near Rappahannock River; Wythe County, with galena and pyrite at Austinville, Bertha, and Cedar Springs.

Staurolite. Good crossed crystals (fairy stones), have some value as curios; found in Patrick County.

Sunstone. Amelia County, Amelia Courthouse.

Syenite. Suitable for building stone, undeveloped, occurs in Carroll County, northeastward from Sylvatus and on Big Reed Island Creek; Charlotte County, from Drakes Branch to near Charlotte Courthouse; Floyd County, in northwest corner; Greene County, near Elkton; Madison County, at Milams Gap; Warren County, along west side of Blue Ridge, near Front Royal.

Talc. Found in commercial quantity and mined in Fairfax County, at several places near Clifton station and Wiehle; Orange County, near Rhoadesville, a small quantity was mined and sawed for crayons and burners in 1911.

Tantalite. Amelia County, fine splendent crystals near Amelia.

Tetradymite. Goochland-Fluvanna counties, Tellurium mine; Spotsylvania County, Whitehall gold mines; Stafford County, Monroe mine.

Tin. *See* Cassiterite.

Tourmaline. Amelia County, in pegmatite dikes in Amelia district, and in some of the quartz veins in the gold belt.

Trap rock. Occurs in many counties in Piedmont region; used for road metal.

Tripolite. *See* Infusorial earth.

Umber. Grayson County, about 2½ miles south of Troutdale; Page County, Milams Gap near Luray; in Blue Ridge of north Virginia and in Blue Ridge of southwest Virginia.

Valley brown ore. Occurs in same general area as mountain brown ore. Associated with limestone. Mines: In Augusta County, Lofton; Page County, Luray; Pulaski County, Reed Island; Rockbridge County, Midvale; Wythe County, Foster Falls and Ivanhoe.

Verde antique. Loudoun County, occurs on Goose Creek, not used.

Wad. Augusta County, with other manganese ores at Crimora and in siliceous rock near Waynesboro; Rockingham County, interbedded with clay at Kendall and Flick mine near Elkton.

Wolframite. Rockbridge County, with cassiterite in Irish Creek area.

Zinc minerals. *See* Calamine, Sphalerite, and Smithsonite.

Zircon. Amelia County, in pegmatite dikes in Amelia district; Hanover County, as zirconiferous sandstone of Calvert age, 3 miles west of Ashland.

WASHINGTON.

Antimony. *See* Stibnite.

Argentite. Okanogan County, Moses (Nespelem) district, in Apache and Little Chief mines; Stevens County, Deer Trail (Cedar Canyon) district, at Silver Queen and Orchid mines.

Arsenic (native). Snohomish County, Monte Cristo. *See also* Arsenopyrite, Realgar.

Arsenopyrite (arsenical pyrite). King County, Mono claims near Berlin and Apex mine; Okanogan County, Twisp and Squaw Creek districts, mined for gold; Snohomish County, principal ore in Monte Cristo district; with chalcopyrite in Stilaguamish district, mined for gold and silver; mined also near Everett for gold, silver, and arsenic.

Asbestos. Chelan County, developed property near Leavenworth, occurs in Mount Stuart and Wenatchee Mountains but not mined; occurs in huge quantity along Columbia River and through Cascade Mountains.

Basalt. Most abundant surface rock in State. Quarried at following places: Clarke County, Fishers Landing, 10 miles above Vancouver; King County, Franklin and Riverton; Lewis County, Meskill; Spokane County, Marshall; Walla Walla County, Dixie; Yakima County, North Yakima.

Bismuth. *See* Cosalite.

Bornite (purple copper ore). King County, Climax claims southwest of Baring, carries silver; Pierce County, Surprise claims, Carbon River district; Snohomish County, important ore at Index prospects.

Brown iron ore (limonite). Snohomish County, Monte Cristo district, mined for gold and silver; Stevens County, prospects near Deep Creek Lake southeast of Northport.

Cassiterite (tin ore). Spokane County, in pegmatite cutting Archean gneiss, quartzites, and schists at Silver Hill 12 miles southeast of Spokane; has been prospected.

Cement material. *See* Limestone.

Cerargyrite (horn silver). Stevens County, occurs with lead ores in Cedar Canyon district; mined and shipped from Orchid.

Cerussite (lead carbonate). Stevens County, argentiferous, occurs in Cleveland, Colville, and Summit mining districts; has been mined.

Chalcocite (copper glance). Lewis and Skamania counties, St. Helena district, not mined; Snohomish County, Index district, mined at Ethel and Independent mines.

Chalcopyrite (copper pyrite). Chelan County, claims in Horseshoe Basin and Railroad Creek district, carries gold and silver; King County, chief mineral of Climax claims near Baring and Dutch-Miller, carries gold and silver; Lewis and Skamania counties, St. Helena district, auriferous; Okanogan County, Myers Creek, Palmer Mountain, Upper Methow, Twisp Creek, and Squaw Creek districts, carries gold and silver; Pierce County, a number of claims in Carbon River district; Snohomish County, one of chief ores of Monte Cristo district, mined for gold and silver; principal gold ore of Stilaguamish district; mined for gold and silver at Index district; Stevens County, Copper King mine, Chewelah.

Clay (brick). Bricks are made from local clay deposits at the principal towns in more than half of the counties. Pits at the following places: Chehalis County, at Aberdeen; Chelan County, Chelan and Wenatchee; Clarke County, Vancouver; Columbia County, Dayton; Cowlitz County, near Olequa; Ferry County, near Republic; King County, near Seattle, Taylor, Renton, Kummer, Van Asselt, Woodinville, and elsewhere; Kitsap County, Harper; Kittitas County, Clealum; Lewis County, Centralia, Chehalis, and Little Falls; Lincoln County, Irby; Okanogan County, Okanogan; Pierce County, Fox Island; Skagit County, Alger; Snohomish County, Everett; Spokane County, Deer Park, Freeman, Spokane, and elsewhere; Stevens County, Chewelah, Clayton, and Springdale; Walla Walla County, Walla Walla; Whatcom County, Bellingham; Whitman County, Colfax, Oakesdale, Palouse, and elsewhere; Yakima County, mined in valley of Yakima River near North Yakima and at Granger.

Clay (fire). Cowlitz County, occurs 2 miles east of Sopenah; Spokane County, small quantity mined at Mica; Stevens County, occurs at Northport.

Clay (kaolin). Pierce County, occurs at Eatonville.

Clay (pottery). Cowlitz County, occurs along Cowlitz River a few miles above Olequa and 2 miles east of Sopenah; dug at Sopenah; King County, small quantity dug at Auburn; Whitman County, occurs along Palouse River near Palouse.

Coal (bituminous and subbituminous). King County, Green River district, highly bituminous; mined at Pocahontas mine; Kittitas County, Roslyn-Clealum district, excellent quality; mined at Roslyn and Clealum mines, 4–5½ feet thick; shipped; Pierce County, Wilkeson-Carbonado district, lying midway between Tacoma and Mount Rainier; 6 beds worked at Wilkeson mine; 4 beds worked at Carbonado mine, 4–7 feet; coking and steam; Whatcom County, Blue Canyon mine on southeast shore of Lake Whatcom, 7 feet.

Coal (subbituminous and lignite). Cowlitz County, Kelso-Castle Rock district, mined on Coal Creek, 8 miles west of Kelso; shipped; King County, Newcastle-Issaquah district, 7 beds worked at Issaquah mine; 4 beds at Coal Creek mine, 3–14 feet; Renton-Cedar district, mined at Cedar Mountain mine near Renton, 8 feet; Green River district, mined at Gem mine near Franklin, and Lawson mine near Black Diamond; Lewis County, Chehalis-Centralia district, mined near Centralia, bed 5½ feet; small mine near Chehalis, bed 4 feet; Thurston County, mined 4 miles from Tenino.

Coal (semianthracite). Whatcom County, number of coal beds in coal measures on Glacier Creek; prospects.

Cobalt. Ferry County, occurs near Keller.

Copper minerals. Copper is the predominant metal produced in the following districts: Ferry County, Belcher, Lone Star, Sanpoil; Okanogan County, Osoyoos Lake (Oroville); Pierce County, Carbon River (Fairfax station); Skagit County, Bald Mountains, 10 miles south of Lymon; Snokomish County, Index, Silver Creek, Stilaguamish; Stevens County, Chewelah; of minor importance in many other districts. *See also* Bornite, Chalcocite, Chalcopyrite, Malachite, Melaconite, and Tetrahedrite.

Copper (native). Pierce County, rare; found at Eatonville.

Cosalite (argentiferous). Stevens County, with wolframite at Cedar Canyon and with hübnerite at Loon Lake; not saved.

Galena. Chelan County, claims in Horseshoe Basin district, gold and silver; Lewis and Skamania counties, claims in St. Helens district; Lincoln County, has been mined for silver at Crystal mine, 1½ miles east of mouth of Spokane River; Okanogan County, mined for gold and silver at Monterey and Yakima mines, Myers Creek district, and Golden Zone and Gold Hill mines, Palmer Mountain district; Snohomish County, principal gold and silver ore in Monte Cristo and Stilaguamish districts; Stevens County, chief silver-bearing mineral at Colville; mined for gold and silver at Deer Trail mines and Silver Queen, Cedar Canyon district; Spokane County, in siliceous veins at Silver Hill; carries silver.

Gold (lode). Gold is the predominant metal produced in the following districts: **Chelan County, Bridge Creek, Entiat, Horseshoe Basin, Lakeside, Leavenworth, Peshastin, Railroad Creek, and Wenatchee; Ferry County, Danville and Republic; King County, Money Creek, 6 miles from Berlin; Kittitas County, Fish Lake, Swauk; Okanogan County, Myers Creek, Nighthawk, Palmer**

Mountains, Squaw Creek, Twisp, Wauconda; Snohomish County, Darrington, Granite Falls, Monte Cristo; Stevens County, Meyers Falls, Orient; Whatcom County, Mount Baker, Slate Creek. Gold occurs in other mining districts but is of less importance than some other metal.

Gold (placer). Asotin County, occurs in black sands of Snake River and at Clarkston, small production; Chehalis County, at Oyhut; Clallam County, at Shishi Beach, Ozette River, and Yellow Bank; Clark County, at Camas and Brush Prairie; Douglas County, in sands of Columbia River. Ferry County, has been mined in sands and gravels of Columbia River at many points between mouths of Kettle and Nespelem rivers; and along Granite Creek near Republic; is mined in small way on Strawberry Creek, a tributary of west fork of Sanpoil River; Kittitas County, Swauk district, 12 placers; Lincoln County, at Davenport and at Hell Gate Bar few miles above Sanpoil and at Peach Bar; Okanogan County, has been mined along Mary Ann Creek, tributary of Myers Creek; Snohomish County, occurs near Silverton; Stevens County, at Wilmot Bar and Marcus; Thurston County, on Wahkiakum Island and Sand Island and along Columbia River; Uinta County, along Snake River and in vicinity of Horse Creek; in the latter prospecting; Whatcom County, in Slate Creek and Mount Baker districts; Yakima County, at Mabton.

Granite. Snohomish County, unlimited supply near Index; Spokane County, quarried at Medical Lake and Spokane; Whitman County, quarried on Snake River, 20 miles below Lewiston and at mouth of Grand Ronde River.

Hematite (red iron ore). Kittitas County, occurs 20 miles north and little west of Clealum; Skagit County, along south bank of Skagit River near Hamilton; Snohomish County, mined for gold and silver in Monte Cristo district; Stevens County, in prospects near Deep Creek Lake, southeast of Northport.

Hübnerite. Stevens County, mined near Loon Lake and Deer Park; occurs with argentiferous cosalite in quartz veins and pegmatite cutting mud stones and granite.

Infusorial earth. Yakima County, formerly mined at North Yakima.

Iron minerals. Iron is the principal metal produced in Kings County, at Snoqualmie Pass; Skagit County, Hamilton; Stevens County, Deep Creek Lake. *See also* Brown iron ore, Hematite, Magnetite, Pyrite, and Pyrrhotite.

Iridosmine. Clallam County, small quantity with gold at Shishi Beach, 2 miles northwest from Point of Arches.

Limestone (building). Snohomish County, quarried 3 miles east of Granite Falls; shipped to Seattle and elsewhere.

Limestone (cement material). Counties of Ferry, King, Okanogan, San Juan, Skagit, Snohomish, Stevens, and Whatcom; limestone suitable for cement making, associated with shale.

Limestone (flux). San Juan County, worked on East Sound, Orcas Island; San Juan Island, deposit extending from Roche Harbor to Westcott Bay, extensively worked; Stevens County, Evans and Northport.

Limestone (lime). Chelan County, burned at Lake Chelan; Ferry County, burned between Republic and Wauconda; King County, near Olga and at Seattle; San Juan County, Orcas Island, Deer Harbor, and Roche Harbor; San Juan Island, deposit extending from Roche Harbor to Westcott Bay, extensively worked; Snohomish County, 3 miles east of Granite Falls; Stevens County, Springdale.

Limonite. *See* Brown iron ore.

Magnetite (magnetic iron ore). In sands of Columbia River placers, northeast Washington, not recovered; King County, in Cascade Mountains, 2½ miles north and west of Snoqualmie Pass: Kittitas County, 20 miles north and a little west of Clealum on Clealum River; Skagit County, deposits along south bank of Skagit River, from Hamilton to Marble Mountain.

lachite. Snohomish County, Monte Cristo district; mined for gold and silver.

rble. Stevens County, large supply at Colville, several quarries; also quarried near Valley and Chewelah; counties of Cowlitz, Okanogan, and Skagit; several kinds of good marble reported.

laconite. Snohomish County, Monte Cristo district; mined for gold and silver.

eral paint. Lead paint is made at Spokane and Tacoma from Idaho and Washington ores. Pierce County, metallic paint mined at Eatonville. *See also* Ocher.

lybdenite (sulphide of molybdenum). Chelan County, in quartz at Crown Point, Railroad Creek district; small quantity has been mined; Ferry County, Sanpoil district, occurs in many prospects; Okanogan County, Golden Zone mine, Palmer Mountain district, with calcite near Conconully; Snohomish County, rare in Monte Cristo district; Stevens County, Metalline district, has been prospected.

nazite. Chehalis County, in black sands at Moclips and Grays Harbor, not recovered; Douglas County, occurs in sands of Columbia River; Stevens County, occurs at Wilmot Bar, Columbia River.

kel. Ferry County, Congress mine near Keller; Okanogan County, Stepstone prospect, 12 miles north of Nespelem.

er. Stevens County, reported at Valley.

l. Whitman Creek near Oregon line, 5 miles northwest of Moscow, has been mined.

troleum. Clallam County, wells were drilled near Lapush at mouth of Solduck River; Okanogan County, Moses (Nespelem) district, Little Chief mine; Thurston County, between Tenino and Grand Mound; Whatcom County, wells drilled at Happy Valley near Fairhaven. No production reported for the State.

tinum. Clallam County, occurs with gold at Shishi Beach; Pacific County, occurs in black sands at Beards Hollows; not recovered.

rargyrite (ruby silver). Okanogan County, Moses district, Little Chief mine; Snohomish County, in gold and silver ores of Forty-Five mine, Stilaguamish district.

ite. Common in many mining districts, as follows: Chelan County, in granite in Holden claims, Railroad Creek district, carries gold and silver; Ferry County, Chesaw mines, northwest of Republic; Lewis and Skamania counties, with copper ores in St. Helens district; Okanogan County, mined for gold and silver at Yakima and Review mines, Myers Creek district, and at Golden Zone and Gold Hill mines, Palmer Mountain district; Snohomish County, gold-bearing in Monte Cristo district, and with galena in Stilaguamish district; Stevens County, scattered through quartz 5 miles northeast of Loon Lake; Whatcom County, large masses of ore exposed in Mount Baker district, carry gold and silver.

rrhotite. Snohomish County, one of chief ores of Monte Cristo district, carries gold and silver. Occurs with chalcopyrite at Silverton, Stilaguamish district, mined for gold.

algar. Lewis County, has been mined for arsenic at Mineral; Snohomish County, has been mined in Monte Cristo district.

ad metal. Chehalis and Thurston counties, basalt between Gate City and Aberdeen; Kitsap County, basalt quarried at Orchard; King County, volcanic rock quarried between South Seattle and Black River Junction. *See also* Basalt.

d (building). Common along entire course of Columbia and other large rivers, in Puget Sound region, and near many large towns; has been dug at following places: Chehalis County, Chehalis River at Aberdeen; King County, Richmond Beach and Vashon Island; Pierce County, Steilacoom and Tacoma.

Sand (molding). King County, dug at Cedar Mountain and Richmond Beach.

Sandstone. Has been quarried at following places: King County, Cumberland; Kitsap County, Bremerton; Pierce County, Wilkeson and Fairfax; San Juan County, East Sound, Provost post office, Steward Island, and Waldron Island; Thurston County, Tenino; Whatcom County, Bellingham district.

Scheelite. Spokane County, associated with quartz at Silver Hill, not mined.

Scorodite. Snohomish County, oxidized ore of Monte Cristo district, mined for gold and silver.

Serpentine. Stevens County, quarried on Green Mountain near Valley.

Silver. Chelan County, with gold ore in Pole Pick mine and in Ivanhoe mine, Peshastin district, and in minor quantity in several other districts; Ferry County, in gold quartz veins at Tom Thumb, Quilp, Lone Pine, Surprise, and other mines near Republic, predominant metal in Meteor district; Lincoln County, principal metal at Crystal district, 15 miles north of Davenport; Okanogan County, in gold-quartz veins in Palmer district, mined at Gold Hill, Black Bear, and War Eagle mines, in Moses (Nespelem) district and in Upper Meteor district; Stevens County, in Chewelah, Deer Trail, Colville, Silver Queen, and other districts; Skagit County, number of claims in Thunder Creek district. *See also* Cerargyrite, Pyrargyrite, and Sylvanite.

Silver (native). Okanogan County, in Apache mine, Moses (Nespelem) district.

Sphalerite (zinc blende). Okanogan County, mined at Yakima mine, Myers Creek district, for gold and silver; Snohomish County, one of chief ores of Monte Cristo district, mined for gold and silver with galena in Stilaguamish district, mined at Forty-Five mine for gold and silver; Stevens County, with galena in Deer Trail (Cedar Canyon) district.

Stibnite. Ferry County, occurs in Enterprise (Covada) district, considerable quantity in Longstreet and other mines and prospects of district; King County, Great Republic mine; Okanogan County, mined near Methon.

Sylvanite. Okanogan County, Squaw Creek district.

Talc. Skagit County, 7 miles above Marblemount, was mined.

Tetrahedrite. Okanogan County, many claims in Squaw Creek district; Snohomish County, Stilaguamish district, mined at Forty-Five mine for gold and silver.

Tin. *See* Cassiterite.

Tufa. Mason County, outcrops along beach 2½ miles on west side of Hoods Canal, has been quarried 2 miles northeast of Hoodsport; Stevens County, extensive deposits on China Bend on Columbia River near Northport; has been quarried.

Tungsten. *See* Hübnerite, Scheelite, and Wolframite.

Wolframite. Okanogan County, occurs 35 miles northwest of Loomis near Cathedral Peak, development in progress; Spokane County, associated with quartz at Silver Hill; Stevens County, mined at Germania mine, Deer Trail (Cedar Canyon district.

WEST VIRGINIA.

Barite (heavy spar). Mercer County, on north slope of East River Mountain; not mined.

Bromine. Manufactured from brine in Kanawha County, at Malden; Mason County, Hartford and Mason.

Brown iron ore (brown hematite, limonite). Berkeley County, south of Martinsburg, pits were opened and ore shipped; Grant County, Greenland Gap, has been mined; Greenbrier County, prospects near Anthony Creek Gap; Hampshire County, near Capon Springs, on ridges north of Capon Springs; Hardy

County, has been mined at number of places near Wardensville; Jefferson County, ore bank 4 miles above Harpers Ferry, has been mined; Mineral County, has been mined near Keyser; Monroe County, considerable quantity in Zenith area, in flint and lime at Crimson Spring; prospects on Peters Mountain and elsewhere, has been mined at Crimson Spring; Morgan County, Sandy Ridge; Pendleton County, at many places along North Fork Mountain; prospects on sides of Little Mountain, 2 miles east of Franklin; Pocahontas County, prospects on Beaver Lick Mountain; Raleigh County, has been mined near Beckley.

Cement material. Jefferson County, Cambrian limestone used for natural cement near Shepherdstown; Mineral County, Lewistown limestone quarried at Cedar Cliff; Preston County, Greenbrier limestone used at Manheim on Cheat River, for Portland cement. Occurs, but not used for cement in Berkeley County, near Martinsburg; Jefferson County, Charlestown, and Millville; Mineral County, near Keyser; Monongalia County, along Cheat River, 6 miles east of Morgantown, and on Deckers Creek; Tucker County, in vicinity of Hendricks.

Cement material (calcareous tufa, travertine, calcareous marl). Grant County, Patterson Creek; in Hardy, Hampshire, Jefferson, and other counties, in large deposits; not mined.

Clay (brick). Dug and used at following places: Barbour County, Philippi; Berkeley County, near Martinsburg; Cabell County, Barboursville, Central City, Culloden, Huntington, and Milton; Greenbrier County, Caldwell; Hancock County, New Cumberland and Zalia; Harrison County, Clarksburg, and Glen View; Jackson County, Ripley and Ravenswood; Jefferson County, Shepherdstown; Kanawha County, Charleston and South Ruffner; Lewis County, Janelew and Weston; Marion County, Colfax, Fairmont, and Hammond; Marshall County, Moundsville; Mason County, Huntington, Point Pleasant, and Spilman; Mineral County, Ridgeley; Mingo County, Williamson; Monongalia County, Morgantown and Randall; Preston County, Kingwood; Putnam County, Bancroft; Randolph County, Elkins; Ritchie County, Pennsboro; Roane County, Spencer; Taylor County, Colfax and Thornton; Tyler County, Middlebourne; Upshur County, Buckhannon; Wetzel County, Brooklin and New Martinsville; Wood County, Parkersburg.

Clay (fire). Barbour County, flint clay 1 mile east of Junior; Braxton County, near Savageville, has been mined; Hancock County, occurs in vicinity of New Cumberland; Harrison County, occurs 1 mile east of Clarksburg; Kanawha County, near Charleston, has been mined; Marion County flint and plastic clay worked at Hammond; Mineral County, occurs 1 mile east of Piedmont; Monongalia County, occurs near Morgantown; Preston County, occurs along Cheat River; Taylor County, occurs near Lost Run, Thornton; Tucker County, North Fork of Blackwater; Wayne County, occurs near Cassville.

Clay (stoneware). Has been dug and used at following places: Harrison County, Bridgeport; Jackson County, Ravenswood; Monongalia County, Morgantown; Wood County, Parkersburg; occurs in Randolph County, at Elkins.

Coal (bituminous and semibituminous). Over 20 workable coal beds in State; hundreds of mines; coal all of Carboniferous age; mined in Barbour, Boone, Braxton, Brooke, Cabell, Clay, Doddridge, Fayette, Gilmer, Grant, Greenbrier, Hancock, Harrison, Kanawha, Lewis, Lincoln, McDowell, Marion, Marshall, Mason, Mineral, Mingo, Monongalia, Nicholas, Ohio, Pleasant, Preston, Putnam, Raleigh, Randolph, Ritchie, Roane, Taylor, Tucker, Upshur, Wayne, Webster, Wetzel, and Wyoming counties. Bituminous coal in all these counties except Fayette, McDowell, Mercer, Raleigh, and Wyoming, where the coal is mostly the semibituminous and high-grade bituminous, smokeless coal, of the New River and Pocahontas fields.

Fluorspar. Jefferson County, Shepherdstown, not mined.

Grahamite (asphalt). Ritchie County, was once extensively mined 25 miles southeast of Parkersburg, and is still mined there in a small way.

Grindstone. Has been quarried: Jackson County, at Lone Cedar, 21 miles south of Parkersburg; Kanawha County, on north side of Kanawha River, at Sattes; Upshur County, Buckhannon; Wood County, north of Parkersburg.

Halite. *See* Salt.

Hematite (red iron ore). Grant County, prospects in southeastern part, South Fork Mountain; Hardy County, has been mined near Wardensville and Perry; Mineral County, has been mined 1 mile southeast of Keyser; Monongalia County, location of several early furnaces which used local ore.

Hematite (fossil ore). Grant County, vicinity of Greenland Gap, parallel seams 5 feet thick, has been mined; Greenbrier County, Anthonys Creek and Howard Creek, prospected, both fossil and black ore; Hardy County, middle and also on north mountain ranges, large bodies developed; Mercer County, north slope of East River Mountain, Bluestone River, on Black Oak Mountains, and Flat Top Mountains, prospected; Monroe County, Little Mountain, prospected; Pendleton County, South Fork Mountains, prospected.

Iron ore. *See* Brown iron ore, Hematite, Ocher, and Siderite.

Limestone (building). Quarried: Greenbrier County, at Lewisburg; Jefferson County, near Charlestown, at Millville, and Shepherdstown; Preston County, small quantity quarried at Orr, also 1 mile west of Corinth.

Limestone (crushed stone). Quarried: Greenbrier County, at Fort Spring; Jefferson County, Keller and three-fourths mile west of Engles Siding; Mineral County, Keyser; Monongalia County, Sturgisson; Monroe County, near Frazier; Ohio County, near Wheeling; Preston County, Afton.

Limestone (flux). Berkeley County, has been quarried for flux at Bunker Hill and Martinsburg.

Limestone (lime). Burned for lime: Berkeley County, at Bunker Hill; Greenbrier County, Fort Spring; Jefferson County, Millville; Monroe County, Snowflake; Preston County, Afton, Cranesville, and elsewhere.

Limonite. *See* Brown iron ore.

Manganese ore. Greenbrier County, in Oriskany iron ores at Glenmore; not mined.

Mica (muscovite). Berkeley County, large muscovite scales in Slate district, 13 miles west of Blue Ridge; not mined.

Natural gas. Produced in 1910 to 1912 more than any other State; from wells in Boone, Braxton, Brooke, Cabell, Calhoun, Clay, Doddridge, Gilmer, Hancock, Harrison, Kanawha, Lewis, Lincoln, Marion, Marshall, Monongalia, Ohio, Pleasants, Putnam, Ritchie, Roane, Taylor, Tyler, Upshur, Wayne, Wetzel, Wirt, and Wood counties. Wells range in depth to 4,000 feet.

Niter (saltpeter). Found in caves in Greenbrier, Monroe, and Pocahontas counties; has been used.

Ocher. Cabell County, on Guyandotte River; Hardy County, South Branch Valley; Jefferson County, Lost River, near Harpers Ferry and near Shepherdstown; Lewis County, yellow ocher near Weston; Pendleton County, Clines Crossroads; Wayne County, near Ceredo; not mined.

Petroleum. Produced in Brooke, Cabell, Calhoun, Doddridge, Gilmer, Hancock, Harrison, Kanawha, Lewis, Lincoln, Marion, Marshall, Monongalia, Ohio, Pleasants, Putnam, Ritchie, Roane, Tyler, Wayne, Wetzel, Wirt, and Wood counties; Harrison and Lincoln counties produced over 1,000,000 barrels each in 1909. Producing wells numbering about 13,000 and ranging in depth from 215 to 3,580 feet, yielded more than 12,000,000 barrels in 1912.

Pyrite. Berkeley County, in Slate district, 13 miles west of Blue Ridge, not mined.

Quartz (sand). Hampshire County, Blue Gap, Short Mountain, cliffs of white sand rock; Monongalia County, near Morgantown, very soft sandstone; Morgan County, Sir Johns Run, not used.

Salt (brine). Obtained: Kanawha County, near Malden; Mason County, at Hartford and Mason; Wood County, Kanawha. Production over 180,000 barrels of salt in 1911. Salt has been made from brine wells at following places: Braxton County, Bulltown, on Little Kanawha; Clay County, at mouth of Otter Creek, on Elk River; Mercer County, New River; Monongalia County, along Cheat River, Deckers Creek, and Scotts Run, in borings for oil; and at other localities.

Sand (building). Dug and used at following places: Cabell County, at Huntington; Kanawha County, Charleston and on Elk River; Marshall County, Moundsville; Mason County, Hogsett; Monongalia County, Star City; Morgan County, Berkeley Springs; Ohio County, Wheeling; Preston County, Holmes station; Taylor County, Grafton; Upshur County, Buckhannon and Ivanhoe; Wood County, near Parkersburg.

Sand (glass). Monongalia County, Homewood sandstone member of the Pottsville formation, quarried on Deckers Creek at Sturgisson, 9 miles southeast of Morgantown; Morgan County, large quarries in Oriskany sandstone near Berkeley Springs, large deposits of white sand are worked and shipped for glass manufacturing; Preston County, Holmes station and near Independence, Homewood sandstone member of Pottsville formation; Randolph County, has been quarried at Silica; Taylor County, has been quarried near Grafton; Upshur County, early Pennsylvanian sandstone was quarried at Craddock.

Sand (molding). Dug in Cabell County, at Huntington; Monongalia County, at Star City; and other places.

Sandstone. Barbour County, quarried at Philippi and vicinity, and near Laurel; Braxton County, near Gassaway, and small quarry at Frametown; Brooke County, near Wellsburg, local use; Cabell County, small quarry 2 miles southwest of Huntington; Hancock County, Kings Creek and below New Cumberland; Harrison County, Clarksburg; Jackson County, Sherman and Murrayville; Kanawha County, Charleston and Sattes; Lewis County, Weston; McDowell County, Gary; Marion County, Farmington and near Fairmont; Mineral County, Bloomington; Monongalia County, quarried at Morgantown and Sturgisson; Monroe County, has been quarried near Alderson; Pleasant County, quarried on small scale at St. Marys; Preston County, Bowlesburg, Albright and Zevely; Randolph County, Kingsville; Ritchie County, Cornwallis and Harrisville; Summers County, has been quarried near Hinton; Taylor County, quarried at Grafton, Yates, and Fetterman; Tyler County, Sisterville; Wetzel County, Littleton, New Martinsville; Upshur County, Buckhannon; Wood County, near Parkersburg.

Siderite (carbonate of iron). Has been prospected or mined in small way at following places: Barbour County, near Philippi; Braxton County, mouth of Strange Creek; Clay County, has been worked by Elk River Iron Co., Standing Rock Run; Grant County, thin seams at several localities; Kanawha County, near Charleston; Marion County, Fairmont; Mineral County, thin seams at several localities; Monongalia County, Deckers Creek, Scott Run, Booth Creek, and Cheat River, eastern part; Preston County, Three Forks Creek, Reedsville, Tunnelton, and Muddy Creek; Taylor County, near mouth of Lost Run; Wayne County, eight seams 1 to 3 feet thick on Big Sandy River at Cassville.

Siderite (black band ore). Has been mined: Clay County, on Little Sycamore Creek of Elk River; Fayette County, Bell Creek; Kanawha County, Davis and Briar creeks; Nicholas County, Little Elk Run; Wayne County, near Big Sandy River.

Slate. Berkeley County, rather inferior quality quarried 3 miles northeast of Martinsburg.

WISCONSIN.

Arsenopyrite. Oconto County, found in vein in granite quarry south of Mountain.

Asbestos (actinolite). Portage County, has been mined near Stevens Point.

Azurite (blue carbonate of copper). Grant, Iowa, and Lafayette counties, found at several points in lead and zinc district.

Barite (heavy spar). Grant, Iowa, and Lafayette counties, deleterious gangue mineral, abundant in certain of the lead and zinc mines.

Brown iron ore (bog iron ore). Juneau County, near Necedah; Wood County, Grand Rapids; in many other localities in marshes of central and northern Wisconsin; not mined.

Brown iron ore (brown hematite, limonite). Florence County, accompanies hard hematite ore at Commonwealth and Florence mines; Grant, Iowa, and Lafayette counties, in minor quantities in ore-bearing crevices and in pockets of rock of the lead and zinc region; Pierce County, mined and smelted at Spring Valley; Sauk County, Ironton, Westfield, and elsewhere; not mined.

Cement (natural). Milwaukee County, Devonian limestone used for natural cement north of Milwaukee on Lake Michigan, and at Berthelet.

Cerusite (lead carbonate). Grant, Iowa, and Lafayette counties, secondary mineral of lead and zinc mines, mined with galena, which it coats.

Chalcocite (copper glance). Iowa County, Mineral Point copper mines, with chalcopyrite and carbonate.

Chalcopyrite (copper pyrites). Florence County, found in quantities sufficient to encourage exploration in green schists south of Homestead settlement, in south eastern part of county; Grant, Iowa, and Lafayette counties, has been mined at several points in lead and zinc region; Oconto County, in vein in granite near Mountain; Richland and Vernon counties, occurs sparingly in Cambrian ("Potsdam") sandstone.

Clay (brick). Dug and worked near almost every large town in the State. Production of common brick in 1911 valued at $985,824.

Clay (kaolin). Barron County, occurs at Rice Lake, sec. 19, T. 35 N., R. 9 W.; St. Croix County, Hersey, washed and sold to paper manufacturers; excellent kaolin in vicinity of Glenwood; not used.

Clay (pottery). Rock County, terra-cotta ware made at Edgerton, from mixture of Edgerton white burning and Springfield red burning clay.

Clay (shale). Eau Claire County, large supply of pre-Cambrian shales suitable for brick, near Eau Claire; not used.

Copper (native). Ashland County, occurs in veins, amygdules, and scattered through epidotized trap, and in sandstone, on Montreal and Bad rivers; Bayfield County, in southwestern part of county; Douglas County, in Annicon, Brule, and Black rivers; Iowa County, has been mined at Mineral Point. Float bowlders common in eastern Wisconsin. Found at many points in upper Mississippi lead region.

Copper ores. *See* Azurite, Chalcocite, Chalcopyrite, and Malachite.

Feldspar. Marathon County, in pegmatite at Stettin, about 5 miles northwest of Wausau, not mined.

Flint. Abundant in certain parts of Galena dolomite in Grant, Iowa, and Lafayette counties, and in Niagara dolomite in eastern part of State; not used.

Galena. Original lead ore of upper Mississippi Valley; Grant County, mined at Platteville, Cuba City, and Hazel Green; Iowa County, occurs at Mifflin, Highland, Montfort, Livingston, Linden, Mineral Point district, and Dodgeville; Lafayette County, Benton and Shullsburg; Green County, has been mined near Monroe.

Granite. Quarried: Marathon County, at Granite Heights and Wausau; Marinette County, Athelstane and Amberg; Marquette County, Montello; Waupaca County, Waupaca; Waushara County, Lohrville, Neshkoro, Red Granite, and Warren. Occurs: Jackson County, at Black River Falls; Lincoln County, Irma; Wood County, abundant at Jenny Bull Falls; and at many other places.

Granite (porphyry). Wood County, has been quarried near Dexterville, on Yellow River.

Graphite. Portage County, amorphous graphite mined at Junction City.

Hematite (red hematite). *Menominee Range.*—Western extension is worked extensively at Commonwealth and Florence mines, in T. 40 N., R. 18 E., in Florence County. Beds of great thickness in Huronian rocks. Hard red ore accompanied by some limonite.

Penokee-Gogebic Range.—Large deposits, upon which a number of mines are working in eastern side of Iron County. The deposits occur in pitching troughs formed by the intersection of "greenstone" dikes and the footwall quartzite. Ore is mostly a soft red or brownish-red hematite with a little hard, steely, specular hematite.

Baraboo Range.—Deposits of red hematite ore in Huronian iron-bearing rocks in Sauk County; several mines being developed.

Iron Ridge.—"Clinton" or "fossil" ore near Mayville, Dodge County, in a lens-shaped bed.

Iron minerals. *See* Brown iron ore, Hematite, Magnetite, Marcasite, Ocher, and Pyrite.

Kaolin (porcelain clay and fire clay). Jackson and Wood counties, along junction of Laurentian and Cambrian rocks; Wood County, well exposed at Grand Rapids, and worked for fire brick.

Lead minerals. *See* Cerusite and Galena.

Limestone (building). Quarried in following places: Brown County, at De Pere and Duckcreek; Buffalo County, Fountain City, Marshland, and Bluff Siding; Calumet County, Chilton; Crawford County, Bridgeport; Dodge County, near Foxlake and at Knowles; Door County, Sturgeon Bay; Fond du Lac County, small quantity quarried at Waupun and in vicinity of Marblehead; Grant County, Boscobel and Cassville; Iowa County, Mineral Point and Spring Green; Jefferson County, Watertown; Kewaunee County, small quantity quarried at Kewaunee; La Crosse County, Holmes, La Crosse, Mindora, and West Salem; Lafayette County, Darlington; Manitowoc County, Cooperstown; Milwaukee County, Wauwatosa and Milwaukee; Oconto County, very small quantity quarried at Little Suamico; Outagamie County, Appleton, Dale, Hortonville, Kaukauna, Seymour, and elsewhere; Ozaukee County, Cedarburg; Pepin County, Pepin; Pierce County, Elmwood and Maiden Rock; Polk County, in vicinity of Osceola; Racine County, small quantity quarried at Burlington; Rock County, Beloit and Edgerton; St. Croix County, small quantity quarried at River Falls; Sheboygan County, Sheboygan; Trempealeau County, very small quantity quarried at Trempealeau; Vernon County, Stoddard and Viroqua; Walworth County, small quantity quarried at Whitewater; Waukesha County, Lannon, Genesee, and Waukesha; Winnebago County, Neenah, Nenasha, Oshkosh, Omro, and Winneconne; Wood County, small quantity quarried at Grand Rapids.

Limestone (crushed stone). Quarried at following places: Brown County, at Green Bay, De Pere, Duckcreek, and Greenleaf; Buffalo County, Alma and Fountain City; Calumet County, Brillion and Chilton; Dane County, Madison;

Dodge County, near Foxlake, Knowles, and Richwood; Door County, Sebastopol, Sturgeon Bay, and Sawyer; Fond du Lac County, Hamilton, Marblehead, Oakfield, and Waupun; Grant County, Boscobel, Cassville, and Lancaster; Iowa County, Mineral Point; Jefferson County, Watertown; Kewaunee County, Kewaunee; La Crosse County, La Crosse and Onalaska; Lafayette County, Burlington; Manitowoc County, Quarry and Valders; Milwaukee County, Wauwatosa and Milwaukee; Monroe County, Sparta; Outagamie County, Appleton, Black Creek, Hortonville, Kaukauna, and elsewhere; Ozaukee County, Cedarburg, Druecker, and Grafton; Racine County, Burlington and Racine; Rock County, Janesville; Sheboygan County, Sheboygan and Sheboygan Falls; Trempealeau County, Galesville; Vernon County, Stoddard and Viroqua; Waukesha County, Lannon and Waukesha; Winnebago County, Neenah, Omro, and Oshkosh.

Limestone (flux). Quarried: Dodge County, at Knowles and Mayville; Fond du Lac County, Hamilton.

Limestone (hydraulic, water lime, cement rock). Fond du Lac County, quarried at Ripon; Milwaukee County, has been quarried at Milwaukee; Winnebago County, has been quarried at Poygan.

Limestone (lime). Quarried in following places: Buffalo County, at Alma; Calumet County, Brillion, Clifton, and elsewhere; Dodge County, Knowles and Mayville; Door County, Baileys Harbor, Fish Creek, and elsewhere; Fond du Lac County, Hamilton and Marblehead; Green County, Martintown; Kewaunee County, Kewaunee; Lafayette County, Darlington; Manitowoc County, Grimms, Manitowoc, and Quarry; Oconto County, Chase and Gillette; Outagamie County, Black Creek; Ozaukee County, Cedarburg, Druecker, and Grafton; Pierce County, Elmwood; Racine County, in vicinity of Racine; Trempealeau County, Arcadia; Vernon County, Stoddard; Washington County, Rockfield and South Germantown; Waukesha County, Templeton.

Limonite. *See* Brown iron ore.

Magnetite. Ashland and Bayfield counties, in quartzites and slates of the Huronian in Penokee range; Chippewa County, Penokee Gap, along Chippewa River, mixed magnetic and hematite ores, ferruginous schists; Florence County, found in small quantities in Commonwealth iron ores, and in slates and schists, associated with ores and lean iron-bearing rocks; not mined; Jackson County, Black River Falls.

Malachite (green carbonate of copper). Iowa and Lafayette counties, found at several points in lead and zinc region, not mined.

Manganese. *See* Wad.

Marcasite (white iron pyrites). Iowa County, accompanies sphalerite near Dodgeville; Lafayette County, common with lead and zinc ores in mines near Hazel Green, Meekers Grove, Strawbridge, and Sullsburg; mined.

Ocher. Juneau County, brown ocher has been mined; Waupaca County, red and yellow ocher at Clintonville.

Peat. Underlying many bogs and swamps; attempted use not yet successful.

Porphyry (quartz porphyry). Columbia County, Marcellon; Marquette County, Moundsville; Green Lake County, Berlin and Utley, has been quarried. *See also* Rhyolite.

Pyrite (iron pyrites). Grant County, mined at Platteville. Abundant in some lead and zinc mines associated with galena and sphalerite, as in Iowa and Lafayette counties.

Quartzite. Quarried: Dodge County, near Portland; Jefferson County, at Waterloo; Juneau County, occurs in large quantities near Necedah; Marathon County, Albeman, Baraboo, and Wausau, for sandpaper.

Rhyolite. Green Lake County, quarried at Berlin and Utley. *See also* Porphyry.

Sand (building). Dug at following places: Ashland County, on Oak Island; Fond du Lac County, at Ripon; Kenosha County, Kenosha and Wilmot; Marathon County, Wausau and Rib River; Marinette County, Marinette; Milwaukee County, Milwaukee; Monroe County, Tomah; Racine County, Burlington; Rock County, Janesville and Beloit; Walworth County, Fontana; Waukesha County, Waukesha.

Sand (glass). Dug in Columbia County, at Portage; Monroe County, Tomah; Rock County, Beloit. St. Peter sandstone in many localities, as at Waukau, Winnebago County; not used.

Sand (molding). Dug in following places: Columbia County, Portage; Fond du Lac County, Fairwater; Green Lake County, Berlin; Racine County, Burlington and Racine; Rock County, Beloit.

Sand and gravel. Occur all over eastern and northern portions of State, used locally as road material and for concrete work. Principal deposits, Kenosha County, along Fox River, near Camp Lake and Wilmot; Rock County, near Janesville; and Walworth County, Fontana.

Sandstone. Keweenawan sandstone outcrops on shore of Lake Superior, from Ashland to Superior; Bayfield County, quarried at Houghton, Port Wing, and Siskiwit Point. Cambrian ("Potsdam") sandstone is quarried at Chippewa County, Chippewa Falls; Clark County, abundant in vicinity of Neillsville; small quantity quarried in Crawford County, at Prairie du Chien; Dane County, Madison; Dodge County, near Portland; Dunn County, Colfax and Dunnville; Jackson County, near Black River Falls and at Alma; Juneau County, Mauston; LaCrosse County, Holman, small quantity; Lafayette County, Argyle and Darlington; Monroe County, small quantity quarried at Sparta; Outagamie County, Black Creek; Pepin County, Durand; Portage County, Stevens Point, harder beds used for paving blocks; St. Croix County, small quantity quarried; Sauk County, Ableman, Baraboo, and North Freedom; Trempealeau County, Arcadia, Galesville, and Independence; Waupaca County, near New London; Wood County, small quantity quarried at Grand Rapids and near Centralia.

Smithsonite (carbonate of zinc). Important ore of lead and zinc mines; mined in Grant County; Iowa County, Dodgeville and Highland; and in Lafayette County.

Specularite. Found with hematite. *See* Hematite.

Sphalerite (zinc blende). Most important ore of lead and zinc region: Grant County, mined at Platteville, Cuba City, and Hazel Green; Iowa County, near Dodgeville, Highland, Linden, Mineral Point, Mifflin, Rewey, Montfort, and Livingston; Lafayette County, near Benton, Buncombe, Shullsburg, and Meekers Grove.

Trap rock. Douglas County, quarried at South Range.

Wad. Iowa, Grant, and Lafayette counties, widely distributed in small quantities in lead and zinc mines; St. Croix County, occurs near Wilson and other localities in northern Wisconsin; not used.

Zinc ore. *See* Smithsonite and Sphalerite.

WYOMING.

Agate (moss). Carbon County, has been mined near Sweetwater River; common in other localities; Laramie County, Wilde and Deercorn mine, 2 miles northwest of Guernsey, moss agate, also red and banded; mined intermittently.

Allanite. Albany County, near Albany station; occurs near line between secs. 3 and 10, T. 14 N., R. 78 W., in pegmatite.

Anglesite (lead sulphate). Carbon County, at Ferris, with galena, cerusite, and quartz.

Argentite (silver sulphide). Laramie County, with other ores, Laramie Peak.

Asbestos (chiefly chrysotile). Albany County, Laramie Range; Carbon County, in Seminole Mountains; Converse County, occurs 10 miles south of Glenrock; Crook County, Black Hills; Natrona County, mined on Casper Mountain, 8 miles south of Casper, and on Smith Creek, 20 miles southeast of Casper; fair quality; associated with serpentine; 2 mills erected in 1910; small production in 1911.

Asphalt. Fremont County, occurs 4 miles northeast of Fort Washakie at a depth of 1,500 feet in wells drilled for oil, and in nearly all of the oil districts as maltha or brea, west slope of Bighorn Mountains in secs. 28, 29, 32, 33, T. 52 N., R. 89 W.

Azurite (blue carbonate of copper). Albany County, Rambler and Blanche mines at Holmes, Grand Encampment district; Carbon County, occurs but not mined in Seminole district; Crook County, Warrens Peak; Johnson County, Bighorn Mountains; Laramie County, in Hartville Uplift in many prospects; mined in mines of Copper Belt Co.

Barite (heavy spar). Albany County, Medicine Bow Mountains; not mined; Crook County, Black Hills.

Bentonite. Occurs in Albany, Crook, Johnson, Natrona, and Weston counties; used for weighting paper and as adulterant; has been shipped from Rock Creek, Albany County, and Clay Spur, Weston County; Bighorn County, thick deposits in northern part of Bighorn Basin.

Bismuthinite. Albany County, occurs near Cummings City; not mined.

Bismutite. Albany County, has been mined on Jelm Mountain.

Bornite (purple copper ore). Carbon County, mined at Encampment district; Laramie County, formerly mined about Hartville.

Brown iron ore (limonite). Albany County, occurs at Jelm mines; Converse County, near Douglas; Fremont County, on Little Popo Agie Creek; not mined.

Cassiterite. Crook County. Stream tin has been found sparingly at various times in the gulches around Nigger Hill, S. Dak., on State line.

Cement (Portland). Albany County, 15 feet of pure marl in Niobrara formation, 8 miles southwest of Laramie; Laramie County, Niobrara and Minnekahta limestones and Graneros shale member of the Benton, near Cheyenne; Weston County, near Newcastle; not used.

Cerargyrite (horn silver). Crook County, Black Butte mines, Warrens Peak; Fremont County, associated with other ores in Wind River Mountain mines.

Cerusite (carbonate of lead). Albany County, in schists and diorite at Esterbrook; has been mined and shipped; Carbon County, with galena and quartz at Ferris; Crook County, Black Butte mines, hard and soft carbonates; argentiferous; has been mined.

Chalcocite (copper glance). Albany County, in gneiss and schist at Jelm; gold and silver values; Doane-Rambler and other mines; Carbon County, important ore of Encampment district; Laramie County; important ore in Hartville Uplift; carries gold and silver at some mines.

Chalcopyrite (copper pyrites). Albany County, in granite and schist at Jelm mines; gold values; Carbon County, important ore of Encampment district; Seminole Mountains; Fremont County, South Pass City, with other ores; Laramie County, with iron ores in quartz at Ulcahoma mine, near Hecla; gold and silver values; important ore of Hartville Uplift.

Chromite (chromic iron ore). Converse County, mined at Deer Creek Canyon, 15 miles southwest of Glenrock; Natrona County, similar deposit occurs on Casper Mountain.

Chrysocolla (copper silicate). Laramie County, Hartville iron range; mined at Green Hope, Silver Cliff, and Copper Belt mines.

Clay (brick). Abundant throughout the State. Brick made in the following localities: Albany County, Laramie; Bighorn County, Basin, Cody, Park, and Worland; Carbon County, Encampment; Converse County, Douglas; Crook County, Gillette; Fremont County, Lander and Thermopolis; Laramie County, Wheatland; Natrona County, Casper; Sheridan County, Sheridan; Sweetwater County, Green River.

Coal. Estimated tonnage of coal in the ground second largest in the United States; about 50 per cent of the area of the State is underlain by coal-bearing formations.

Coal (subbituminous). *Bighorn Basin.*—Bighorn and Park counties; mines near Basin, Cody, Gebo, Meeteetse, and Thermopolis.

Powder River field.—Largest in the State; lies between Black Hills and Bighorn Mountains; extends from Montana line south to North Platte River; Upper Cretaceous and Eocene; beds up to 45 feet thick; 11,000 square miles underlain by workable beds; mined at Glenrock, Big Muddy, and Inez station, Converse County; Buffalo, Johnson County; and Carney, Dietz, Monarch, and Sheridan, Sheridan County; small quantity for local use taken at many places.

Wind River Basin.—Fremont-Natrona counties; mined in Popo Agie Valley, 8 miles northeast of Lander; 8 feet.

Coal (bituminous coking). *Cambria field.*—Weston County; large mine at Cambria; about 12 square miles of workable coal; has been coked.

Coal (bituminous and subbituminous). *Green River field.*—Carbon, Fremont, Sweetwater, and Uinta counties; contains 4,800 square miles of available coal, and 20,000 square miles of coal deeply buried. Bituminous coal mined at Hanna and Rawlins, Carbon County; Rock Springs, Sweetwater County; and Cumberland, Diamondville, Kemmerer, and Spring Valley, Uinta County.

Coal (bituminous). *Laramie Basin.*—Albany County, mined for local use at Rock Creek, Dutton Creek, and Mill Creek.

Henrys Fork field.—Uinta County, coal widely distributed; little developed.

Cobalt. Albany County, with gold-copper ores in Medicine Bow mines at Holmes; Laramie County, with copper ores in Silver Crown district.

Copper (native). Albany County, in granite at Rambler mine, Grand Encampment district; Fremont County, Copper Mountain district; Laramie County, Hartville Uplift; mined in Iron Belt mines.

Copper minerals. Copper is the predominant metal produced in the following districts: Albany County, Douglas Creek, Horse Creek, Jelm Mountains, and Laramie Peak; Carbon County, Encampment, French Creek, Rankin, and Seminole; Converse County, Warbonnet; Fremont County, Copper Mountain, De Pass, and Owl Creek; Johnson County, Bull Camp; Laramie County, Rawhide Butte, and Hecla; Natrona County, Casper Mountain; Park County, Sunlight; Uinta County, Cockscomb. *See also* Azurite, Bornite, Chalcocite, Chalcopyrite, Chrysocolla, Covellite, Cuprite, Malachite, and Melaconite.

Corundum (emery). Fremont County, Wind River Range; not mined.

Covellite. Albany County, mined at Rambler mine at Holmes, Grand Encampment district; Laramie County, Hartville Uplift.

Cuprite (red copper oxide). Albany County, Rambler mine at Holmes, Grand Encampment district; Bighorn County, prospects in Bull Creek, Walker Prairie, in Bighorn Mountains; Crook County, associated with hard carbonate ores at Black Buttes and Inyankara Peak; has been mined; Laramie County, mined at Hartville Uplift; prospects in Whalen Canyon, Muskrat Canyon, and Rawhide Buttes.

Epsomite (epsom salt, magnesium sulphate). Long, needle-shaped crystals in soda lakes in Albany, Carbon, and Natrona counties. Brooklyn Lake, area 90 acres, covered with nearly pure deposit, near Wilcox station, Albany County.

Flagstone. Common in same localities as marble, limestone, and sandstones; has been quarried for local use.

Galena (argentiferous). Albany County, mined for gold and silver in gneiss and schist at Jelm; Carbon County, at Ferris in fissure veins with quartz, cerusite, anglesite; Crook County, has been mined at Black Buttes.

Gold (placer). Albany County, Douglas Creek and Keystone; Bighorn County, Shoshone River and Bald Mountain; Carbon County, on the South French Creek; Crook County, Sand Creek and Nigger Hill; Fremont County, Atlantic and Lewiston; South Pass City, hydraulicking in 1912; Wind River near Riverton, dredge being erected; Johnson County, in Kelley Creek near Buffalo, and in Bighorn Mountains; Park County, Shoshone River and Clark Fork at Crandall; Sweetwater County, Green River; Uinta County, in sands of Snake River, mined intermittently, and on Snake Creek.

Gold (lode). Produced in following districts, in most cases as predominant metal: Albany County, Centennial, Holmes, and Jelm Mountains; Crook County, Bear Lodge and Black Buttes; Fremont County, Atlantic, Owl Creek, and South Pass; Laramie County, Rawhide Buttes and Hecla; Uinta County, Horse Creek, 114 miles north of Kemmerer.

Granite. Abundant in Bighorn Mountains, Hartville Uplift, Laramie Range, and Medicine Bow Range; production small.

Graphite (plumbago). Albany County, near Ironton, has been mined; Fremont County, near Miners Delight; Laramie County, Haystack Hills.

Grindstone. Carbon County, quarried near Rawlins; small production.

Gypsum. Albany County, rock gypsum is mined at Red Butte, and used by one mill for making plaster; mined also west of Sheridan; occurs abundantly in Bighorn, Carbon, Converse, Crook, Fremont, Johnson, Laramie, Natrona, Sweetwater, Uinta, and Weston counties. Gypsite, or earthy gypsum, is dug near Laramie, Albany County, and used by two mills for making plaster.

Halite (common salt). In soda lakes in Albany, Carbon, and Natrona counties; salt springs numerous in several counties; Crook County, at Cambria, salt was made by evaporating water of Salt Creek.

Hematite (red iron ore). Carbon County, extensive deposit north of Rawlins was mined for flux; also on south side of the Seminole Mountains, 35 miles north of Rawlins, and at Jelm mines; Laramie County, chief ore of Hartville iron range; mined at Sunrise, Lone Jack, and Good Fortune mines.

Ilmenite (titanic iron ore). Albany County, Iron Mountain; immense dike; not mined.

Iron. Iron is the chief metal produced in Albany County, at Iron Mountain, and Laramie County, Hartville; and chromic iron ore in Converse County, Deer Creek district. *See also* Brown iron ore, Chromite, Hematite, Ilmenite, Magnetite, Pyrite, and Pyrrhotite.

Kaolin. Carbon County, occurs near the soda lakes, pure and in quantity.

Lead. *See* Anglesite, Cerusite, and Galena.

Limestone. Albany County, 3 miles northeast of Laramie City, used for lime in beet-sugar refining. Limestones of Carboniferous and Jurassic age in many counties afford an abundance of good lime suitable for plaster; some of these limestones are hydraulic.

Limestone (building). Quarried: Albany County, at Laramie; Carbon County, Rawlins; Fremont County, Thermopolis; Sweetwater County, Green River.

Limestone (flux). Quarried: Carbon County, at Rawlins; Laramie County, Guernsey.

Limonite (brown hematite). *See* Brown iron ore.

Magnetite (magnetic iron ore). Albany County, in diorite near Fox Park; Carbon County, with hematite, near Rawlins.

Malachite (green carbonate of copper). Albany County, abundant in Rambler mine, and found in Blanche mine at Holmes, Grand Encampment district;

Carbon and Crook counties, prospects at Bull Camp and Walker Prairie in Bighorn Mountains, with other ores; Laramie County, important ore of Hartville Uplift; mined at Green Hope, Silver Cliff, and Copper Belt mines.

Manganese ore. Albany County, west side of Laramie Peak.

Marble. Albany County, west flank Laramie Range; east flank Medicine Bow Range; 100-foot ledge of good quality, Cooper Lake station; Converse County, Douglas, red, good quality; Crook County, west flank Black Hills; Fremont County, Rattlesnake Mountains; Johnson County, Bighorn Mountains; Laramie County, east flank Laramie Range, abundant in the Carboniferous; pure white marble occurs 20 miles west of Wheatland.

Marl. Albany County, 15 feet pure marl, 8 miles southwest of Laramie.

Melaconite (black oxide of copper). Albany County, quantity in Rambler mine, Holmes; Laramie County, Michigan mine.

Mica (muscovite). Albany County, in Medicine Bow Range; Converse County, occurs in sizable plates at Glenrock; Fremont County, 60 miles west of Lander; Laramie County, near Ironton and in Haystack Mountains near Hartville.

Mineral paint. Carbon County, made from soft iron ore at Rawlins; suitable material at Hartville, and other iron localities.

Mirabilite (sodium sulphate; glauber salt). In soda lakes in Albany, Carbon, and Natrona counties; has been mined in Albany County near Laramie, and in Natrona County, Sweetwater Valley.

Monazite. Carbon County, in black sands in Bald Mountain district; Sheridan County, reported from Bighorn Mountains.

Natron (carbonate of soda). Common in soda lakes of Albany, Carbon, Natrona, and Sweetwater counties; not marketed.

Natural gas. Bighorn County, Bighorn gas field on slopes of anticline of Bighorn Mountains; gas used at Basin and Greybull; Converse County, small field at Douglas.

Nickel ore. Converse County, in pyrrhotite, Esterbrook district; Laramie County, in ores of Ulcahoma mine, and associated with copper ores, Little London mine, near Hecla.

Niter. Sweetwater County, soda niter in Leucite Hills.

Ozokerite (mineral wax). Fremont County, occurs 20 miles southeast of Lander; Sweetwater and Uinta Counties, near Colorado line, in Tertiary and Cretaceous; shipped east for use in manufacture of ointments and insulating material.

Palladium. Albany County, in copper ores with platinum in Rambler mine at Holmes.

Petroleum. Bighorn County, Byron field, 22 wells, paraffin base; portion shipped to refinery at Crowley; Converse County, Douglas field, 6 wells, heavy black asphaltum oil; local use; Crook County, Belle Fourche field, 20 miles north of Moorcroft, 9 wells, local use for fuel and lubrication; Fremont County, Dallas field, 39 wells, pipe line 9 miles to Wyopo; Wind River Reservation, 2 wells, pipe line 6 miles to railroad; new field begun at Lander; many wells and two kinds of oil; Natrona County, Salt Creek field, 52 producing wells in 1912; 2 pipe lines 50 miles to Casper; 2 refineries at Casper; Powder River field not producing; Uinta County, Labarge field, along east base of Labarge Range, from Labarge Creek to South Piney, 20 wells; Spring Valley field; numerous small wells from Spring Valley, north, 5 miles; Weston County, several wells near Newcastle got small quantity of oil.

Phosphate rock. Uinta County. Mined and shipped at Cokeville; large area 140 miles long; beds 10 feet thick.

Platinum. Albany County, in copper ores of the Rambler mine, at Holmes; Uinta County, in concentrates from Snake River placers. *See also* Sperrylite.

Potash. Sweetwater County, large quantity in rocks of Leucite Hills; no methods known for making it commercially available

Pumice (volcanic ash). Albany County, beds 4 to 6 feet thick near Sportsmans Lake.

Pyrite (iron pyrites). Albany County, with copper ores, Encampment district, in Jelm and Ulcahoma mines; mined for gold and silver content; Sweetwater and other counties, with gold and quartz veins; little worked.

Pyrrhotite. Albany and Converse counties, underlying iron oxides at Cooney Hill and with copper ores in prospects in North Laramie district.

Salt. Uinta County, mined at Auburn; salt produced from brine south of Star Valley on Salt Creek. *See also* Halite.

Sand (building). Dug in small quantity for local use at many places.

Sand (glass). Albany County, from soft sandstone of Casper formation; has been quarried 3 miles east of Laramie.

Sandstone. Albany County, quarried at Laramie, small quantity; Carbon County, Rawlins; Fremont County, Lander and Thermopolis; Laramie County, Iron Mountain; Uinta County, Cumberland, Evanston, Oakley, Frontier, and Glencoe, and at many other towns and villages.

Shale. Used for brickmaking at Laramie, Albany County.

Silver (native). Laramie County, Silver Cliff mine in Hartville Uplift, and in other copper mines and prospects. *See also* Cerargyrite.

Sperrylite. Albany County, has been found at Rambler mine, Holmes.

Sphalerite. Laramie County, mined with hematite in Hartville mines.

Sulphur. Fremont County, massive and in small crystals in travertine near Thermopolis; mined and shipped; in local deposits on south side of Shoshone River; at lower end of Shoshone Canyon, and on west side of Sulphur Creek; Park County, occurs in the Sunlight Basin, 52 miles northwest of Cody; has been mined near Cody.

Sylvanite. Crook County, recently discovered in Bear Lodge Mountains.

Tennantite. Laramie County, has been mined north of Guernsey in Copper Bottom prospect, SE. ¼ sec. 23, T. 29 N., R. 65 W.

Tenorite. Albany County, quantity at Rambler mine, Holmes.

Tin. *See* Cassiterite.

Trona (sodium carbonate). Sweetwater County, number of wells at Greenwater; produce good soda; shipped.

Wolframite. Albany County, small stringer in copper mine near Holmes.

Wood, silicified. Abundant in Yellowstone National Park.

Zinc. *See* Sphalerite.

GLOSSARY AND INDEX.

The definitions in this glossary are not intended to be sufficiently full and detailed for the determination of unknown minerals. They are expected only to show definitely what is meant by the terms used in the text of the paper. The aim has been to make the definitions as clear as possible for the reader not used to technical terms. However, the intricacies of the subject do not allow that all definitions shall be made perfectly clear to those wholly unfamiliar with minerals or with chemical terms and symbols.

In the hope of adding to the usefulness of the definitions the percentage of those constituents which ordinarily make the mineral of value, and items that may make the relations of the minerals clearer, have generally been given.

Free use has been made of Dana's monumental "System of mineralogy" (6th ed.), Kemp's "Handbook of rocks" (5th ed.), and publications of the United States Geological Survey. The Standard and

Century dictionaries and other standard works have also been consulted.

It is thought that a table of atomic weights will be of use in connection with formulas of the minerals, and therefore the list given by the International Committee on Atomic Weights, 1913, is printed below.

International atomic weights, 1913.[1]

	Symbol.	Atomic weight.
Aluminum	Al	27. 1
Antimony	Sb	120. 2
Argon	A	39. 88
Arsenic	As	74. 96
Barium	Ba	137. 37
Bismuth	Bi	208. 0
Boron	B	11. 0
Bromine	Br	79. 92
Cadmium	Cd	112. 40
Cæsium	Cs	132. 81
Calcium	Ca	40. 07
Carbon	C	12. 0
Cerium	Ce	140. 25
Chlorine	Cl	35. 46
Chromium	Cr	52. 0
Cobalt	Co	58. 97
Columbium	Cb	93. 5
Copper	Cu	63. 57
Dysprosium	Dy	162. 5
Erbium	Er	167. 7
Europium	Eu	152. 0
Fluorine	F	19. 0
Gadolinium	Gd	157. 3
Gallium	Ga	69. 9
Germanium	Ge	72. 5
Glucinum	Gl	9. 1
Gold	Au	197. 2
Helium	He	3. 99
Holmium	Ho	163. 5
Hydrogen	H	1. 008
Indium	In	114. 8
Iodine	I	126. 92
Iridium	Ir	193. 1
Iron	Fe	55. 84
Krypton	Kr	82. 92
Lanthanum	La	139. 0
Lead	Pb	207. 10
Lithium	Li	6. 94
Lutecium	Lu	174. 0
Magnesium	Mg	24. 32
Manganese	Mn	54. 93
Mercury	Hg	200. 6
Molybdenum	Mo	96. 0
Neodymium	Nd	144. 3
Neon	Ne	20. 2
Nickel	Ni	58. 68
Niton (radium emanation)	Nt	222. 4
Nitrogen	N	14. 01
Osmium	Os	190. 9
Oxygen	O	16. 0
Palladium	Pd	106. 7
Phosphorus	P	31. 04
Platinum	Pt	195. 2
Potassium	K	39. 10
Praseodymium	Pr	140. 6
Radium	Ra	226. 4
Rhodium	Rh	102. 9
Rubidium	Rb	85. 45
Ruthenium	Ru	101. 7
Samarium	Sa	150. 4
Scandium	Sc	44. 1
Selenium	Se	79. 2
Silicon	Si	28. 3
Silver	Ag	107. 88
Sodium	Na	23. 00
Strontium	Sr	87. 63
Sulphur	S	32. 07
Tantalum	Ta	181. 5
Tellurium	Te	127. 5
Terbium	Tb	159. 2
Thallium	Tl	204. 0
Thorium	Th	232. 4
Thulium	Tm	168. 5
Tin	Sn	119. 0
Titanium	Ti	48. 1
Tungsten	W	184. 0
Uranium	U	238. 5
Vanadium	V	51. 0
Xenon	Xe	130. 2
Ytterbium (Neoytterbium)	Yb	172. 0
Yttrium	Yt	89. 0
Zinc	Zn	65. 37
Zirconium	Zr	90. 6

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[1] Clarke, F. W., Thorpe, T. E., Ostwald, W., and Urbain, G., Annual report of the International Committee on Atomic Weights, 1913: Am. Chem. Soc. Jour., vol. 34, p. 1439, Nov., 1912.

Abrasives. *See* Burrstone, Corundum, Emery, Garnet, Grindstone, Infusorial earth, Millstone, Novaculite, Oilstone, Pumice, Scythestone, Tripoli, Volcanic ash, Whetstone.

Acanthite. A silver sulphide, Ag_2S. It contains 87 per cent silver.

Colorado.

Actinolite. A light-green calcium-magnesium-iron amphibole, $3Mg(Fe)O.CaO.4SiO_2$. *See* Asbestos.

Ægerite. *See* Wurtzilite.

Ægirite. A monoclinic pyroxene having the general composition, $Na_2O.Fe_2O_3.4SiO_2$. Vanadiferous ægirite near Libby, Mont., contains 4 per cent of V_2O_3, which replaces a part of the Fe_2O_3.

Montana.

Æonite. *See* Wurtzilite.

Agalmatolite. *See* Pyrophyllite.

California, North Carolina.

Agate. A variegated chalcedony, SiO_2.

Arkansas, California, Colorado, Connecticut, Michigan, Montana, Nebraska, New Jersey, North Carolina, Rhode Island, Texas, Wyoming.

Alabandite. Manganese sulphide, MnS.

Colorado.

Alabaster. Compact fine-grained gypsum, white or delicately shaded. *See* Gypsum.

Arizona, California.

Albertite. A jet-black pitchlike, brittle hydrocarbon with conchoidal fracture, differing from ordinary asphalt in being only partly (about 30 per cent) soluble in turpentine and in very imperfect fusion when heated. Specific gravity about 1.1.

Albite, Soda feldspar. A silicate of aluminum and sodium, $Na_2O.Al_2O_3.6SiO_2$. *See* Feldspar.

Allanite, Orthite. A complex variable silicate of aluminum, iron, the cerium metals (cerium, didymium, lanthanum), and in smaller quantity those of the yttrium group.

New York, North Carolina, Texas, Virginia, Wyoming.

Almandite. An iron-aluminum garnet, $3FeO.Al_2O_3.3SiO_2$. Used as a gem (precious garnet).

Colorado, New York, North Carolina, Oregon.

Altaite. A lead telluride, $PbTe$.

Colorado.

Aluminum. A metallic element, Al. Not found native. *See* Bauxite, Halloysite.

Alum salts. Natural salts from which alum can be made. *See also* Halloysite, Kalinite.

Alabama, California, Massachusetts, Nevada, New Mexico, Tennessee, Texas, Virginia.

Alunite. A hydrous sulphate of aluminum and potassium, $K_2O.3Al_2O_3.4SO_3.6H_2O$. It contains 11.4 per cent potash, K_2O.

California, Colorado, Nevada, Utah.

Alunogen. A hydrous aluminum sulphate, $Al_2O_3.3SO_3.18H_2O$.

New Mexico.

Amalgam. A native compound of silver and mercury, in which the percentage of silver ranges from 27.5 to 95.8. Native gold amalgam carrying 39 to 42.6 per cent gold has also been found.

California, Colorado.

Amazon stone. A green microcline, a variety of potash feldspar. Used as a gem.

Colorado, Virginia.

Amblygonite. A fluo-phosphate of aluminum and lithium, $Li(AlF)PO_4$.
California, South Dakota.

Amethyst. A purple or bluish-violet quartz, SiO_2. Used as a gem.
Connecticut, Colorado, Georgia, Maine, Michigan, New Jersey, North Carolina, Pennsylvania, South Carolina, Texas, Virginia.

Amianthus. *See* Asbestos.

Amphibole. A group name for a series of minerals which, although crystallizing in different systems, are closely related in form, as shown by the common prismatic cleavage of 54° to 56°, also in optical characters and chemical composition; they consist essentially of silicates of lime, iron, magnesia, alumina, and in some cases soda. Hornblende is the commonest variety. *See* Asbestos.

Andalusite. An aluminum silicate, $Al_2O_3.SiO_2$. Sometimes used as a semiprecious stone. *See* Chiastolite.
California, Massachusetts.

Andradite. The common calcium-iron garnet, $3CaO.Fe_2O_3.3SiO_2$.
Arizona.

Anglesite. Lead sulphate, $PbSO_4$. Contains 68 per cent lead.
Arizona, California, Colorado, Idaho, Missouri, Nevada, New Mexico, Utah, Wyoming.

Anhydrite. Calcium sulphate, $CaSO_4$ or $CaO.SO_3$. Contains 41.2 per cent lime and 58.8 per cent sulphur trioxide. Usually associated with gypsum, to which it alters. Differs from it in being harder and in lacking water of crystallization.
California, Michigan.

Annabergite. A hydrous nickel arsenate, $Ni_3As_2O_8.8H_2O$.
Nevada.

Anthracite, Hard coal. A hard black lustrous coal containing 85 to 95 per cent carbon as against 70 to 85 per cent in bituminous or "soft" coal. *See* Coal.
Colorado, Massachusetts, New Mexico, Pennsylvania, Rhode Island.

Antimony. An element, Sb. Sometimes found native. *See also* Cervantite, Dyscrasite, Jamesonite, Nagyagite, Polybasite, Stibiconite, Stibnite.
Arizona, Arkansas, California, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Washington.

Antimony glance. *See* Stibnite.

Antimony ocher. *See* Stibiconite.

Apatite. A calcium phosphate containing a little fluorine or chlorine, $Ca_4(CaF)(PO_4)_3$ or $Ca_4(CaCl)(PO_4)_3$. The fluor-apatite contains 42.3 per cent P_2O_5 and the chlor-apatite 41 per cent P_2O_5.
California, Maine, New Jersey, New York, Virginia.

Apophyllite. A calcium-hydrogen silicate sometimes containing potassium and fluorine, $K_2O.8CaO.16SiO_2.16H_2O$. Occasionally used as a gem.
California.

Aquamarine. A transparent light bluish-green beryl. Used as a gem.
Colorado, Connecticut, Massachusetts, North Carolina, South Carolina.

Argentite, Silver glance. A silver sulphide, Ag_2S. Contains 87 per cent silver.
Arizona, Colorado, Idaho, Maine, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming.

Arsenic. An element, As. Sometimes found native. *See also* Arsenopyrite, Mimetite, Niccolite, Orpiment, Realgar, Scorodite, Smaltite, Sperrylite.
California, Montana, Nevada, Virginia, Washington.

Arsenical nickel. *See* Niccolite.

Arsenopyrite, Mispickel. A sulpharsenide of iron, FeAsS. Contains 46 per cent arsenic, equivalent to 57.7 per cent white arsenic, As_2O_3.
Arizona, California, Colorado, Connecticut, Georgia, Idaho, Maine, Montana, Nevada, New Hampshire, New York, North Carolina, Oregon, South Dakota, Vermont, Virginia, Washington, Wisconsin.

Asbestos. A fibrous variety of amphibole. In commerce it includes also fibrous serpentine (chrysotile). Amianthus is a fine silky amphibole asbestos.

Alabama, Arizona, California, Colorado, Connecticut, Delaware, Georgia, Idaho, Maryland, Massachusetts, New York, North Carolina, Oregon, South Carolina, Tennessee, Texas, Vermont, Virginia, Washington, Wisconsin, Wyoming.

Asphalt, Mineral pitch. A complex compound of various hydrocarbons, part of which are oxygenated. Related in origin to petroleum. Is brown or brownish black in color, melts at 90° to 100° F., and is mostly or wholly soluble in turpentine. *See also* Albertite, Elaterite, Gilsonite, Grahamite, Impsonite, Nigrite, Wurtzilite.

Alabama, Arkansas, California, Indiana, Kentucky, Missouri, Nevada, Oklahoma, Texas, Utah, Wyoming.

Auerlite. A silico-phosphate of thorium containing about 70 per cent of thorium. Like zircon in form.

North Carolina.

Autunite. A hydrous phosphate of uranium and calcium; $CaO.2UO_3.P_2O_5.8H_2O$. Contains 62.7 per cent UO_3, equivalent to 61.6 per cent U_3O_8, and is radioactive.

South Dakota, Utah.

Axinite. A boro-silicate of aluminum and calcium with varying quantities of iron and manganese. Exact composition doubtful.

California.

Azurite. Blue copper carbonate, $CuCO_3.Cu(OH)_2$. Contains 46 per cent copper.

Arizona, Arkansas, California, Colorado, Connecticut, Idaho, Missouri, Montana, Nevada, New Jersey, New Mexico, North Carolina, Oklahoma, Oregon, Pennsylvania, South Dakota, Tennessee, Utah, Virginia, Wisconsin, Wyoming.

Azurmalachite. A mixture of blue and green copper carbonates.

Arizona.

Barite, Heavy spar. Barium sulphate, $BaSO_4$.

Alabama, Arkansas, Colorado, Connecticut, Georgia, Kentucky, Maryland, Missouri, Nevada, New Mexico, New York, North Carolina, Oregon, Pennsylvania, South Carolina, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, Wyoming.

Basalt. A dense to glassy dark-colored basic volcanic rock, composed essentially of soda-lime feldspar and pyroxene, with or without olivine, and with accessory magnetite or ilmenite and apatite. The glassy varieties are composed of the uncrystallized constituents of these minerals and are called obsidian.

California (*see* Road metal), Connecticut (*see* Trap rock), Massachusetts (*see* Trap rock), New Jersey (*see* Trap rock), Oregon, Washington.

Bauxite. Hydrated alumina, essentially $Al_2O_3.2H_2O$.

Alabama, Arkansas, California, Colorado, Georgia, Tennessee, Virginia.

Beaverite. A hydrous sulphate of copper, lead, and ferric iron, $CuO.PbO.Fe_2O_3.2SO_3.4H_2O$.

Utah.

Benitoite. A blue barium-titanium silicate, so far found only in California, $BaTiSi_3O_9$. Used as a gem.

California.

Bentonite. A bedded plastic clay which swells immensely upon wetting.

California, Montana, Utah, Wyoming.

Beryl. A glucinum-aluminum silicate, $3GlO.Al_2O_3.6SiO_2$. Used as gem when clear and well colored. The grass-green variety is known as emerald; light-green, beryl; blue-green, aquamarine. Contains 14 per cent glucina (glucinum oxide).

Alabama, California, Colorado, Connecticut, Georgia, Maine, Massachusetts, New Hampshire, North Carolina, Pennsylvania, South Carolina, South Dakota, Utah, Virginia.

Bindheimite. A hydrous antimonate of lead; an oxidation product of jamesonite.
Nevada.

Biotite. A black or brown mica. *See* Mica.

Bismuth. An element, Bi. Found as a native metal. *See also* Bismuthinite, Bismutite, Cosalite, and Tetradymite.
Arizona, California, Connecticut, Nevada, New Mexico, Utah, Washington.

Bismuthinite. Bismuth sulphide, Bi_2S_3. Contains 81.2 per cent bismuth.
Colorado, Connecticut, Nevada, Wyoming.

Bismutite. A basic bismuth carbonate of doubtful composition, perhaps $Bi_2O_3.CO_2.H_2O$. Contains about 80 per cent bismuth.
California, New Mexico, Utah, Wyoming.

Bitumen. *See* Asphalt. A general name for various solid and semisolid hydrocarbons. In 1912 the term was used by the American Society for Testing Materials to include all those hydrocarbons which are soluble in carbon bisulphide, whether gases, easily mobile liquids, viscous liquids, or solids.
California, Tennessee.

Blackjack. *See* Sphalerite.

Black oxide of manganese. *See* Pyrolusite.

Blende. *See* Sphalerite.

Bloodstone. A variety of chalcedony or jasper, dark green in color, interspersed with small red spots. Used as a gem.
California.

Bluestone. The commercial name for a dark bluish-gray feldspathic sandstone or arkose. The color is due to the presence of fine grains of black and dark-green minerals, chiefly hornblende and chlorite. The rock is extensively quarried in New York. Its toughness, due to slight metamorphism, and the ease with which it may be split into thin slabs especially adapt it for use as flagstone. The term has been locally applied to other rocks, among which are dark-blue slate and blue limestone.
New York, Pennsylvania.

Blue vitriol. *See* Chalcanthite.

Bog iron ore. *See* Brown iron ore.

Bog manganese. *See* Wad.

Borax, Tincal. Sodium biborate, $Na_2B_4O_7.10H_2O$, or $Na_2O.2B_2O_3.10H_2O$.
California, Nevada, Oregon, Texas.

Bornite, Erubescite, Peacock copper ore. A sulphide of copper and iron, Cu_3FeS_3. Contains 62 per cent copper.
Arizona, California, Colorado, Connecticut, Idaho, Maine, Maryland, Montana, Nevada, New Hampshire, New Mexico, North Carolina, Oregon, South Dakota, Utah, Virginia, Washington, Wyoming.

Braunite. A somewhat variable manganese silicate, approximately $3Mn_2O_3.MnO.SiO_2$.
Arkansas, Georgia, New Jersey, Vermont.

Brittle silver ore. *See* Stephanite.

Brochantite. A basic sulphate of copper, $CuSO_4.3Cu(OH)_2$.
Arizona, Colorado, New Mexico.

Brongniardite. A lead-silver sulphantimonide, $PbAg_2Sb_2S_5$. Contains 26.2 per cent silver.
Arizona.

Bromine. An element, Br. It does not occur native but is derived in large quantities from brines. Its form of occurrence in the brines is unknown.
Michigan, Ohio, Pennsylvania, West Virginia.

Bromyrite. A silver bromide, AgBr. Contains 57 per cent silver.
Nevada, New Mexico.

Brown iron ore, Limonite, Brown hematite, Bog iron ore. Its approximate formula is $2Fe_2O_3.3H_2O$, equivalent to about 59.8 per cent iron. Probably a mixture of hydrous iron oxides.

Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Idaho, Indiana, Iowa, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, Montana, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming.

Brownstone. *See* Sandstone.

Burrstone. A tough siliceous rock used for millstones. *See* Millstone.

Calamine. A hydrous zinc silicate, $H_2O.2ZnO.SiO_2$. Contains 54 per cent zinc.

Arkansas, Connecticut, Kansas, Maryland, Missouri, Nevada, Oklahoma, Pennsylvania, Tennessee, Virginia.

Calaverite. A telluride of gold and silver, $(Au.Ag)Te_2$. Variable in composition, but contains about 39.5 per cent gold and 3.1 per cent silver.

California, Colorado.

Calciovolborthite. A vanadate of copper and calcium. Contains about 38 per cent V_2O_5.

California, Colorado, Utah.

Calcite. Hexagonal (rhombohedral) calcium carbonate, the more common form of $CaO.CO_2$. Contains 56 per cent lime, CaO.

Kentucky, Minnesota, Missouri, Tennessee.

Caledonite. A green basic sulphate of lead and copper of uncertain composition.

California.

Californite. A compact, massive vesuvianite, used as an ornamental stone.

California.

Carnotite. A canary-yellow mineral, somewhat variable in composition, containing uranium and vanadium, with either or both lime and potash. Is ordinarily a mixture of true carnotite, $2UO_3.V_2O_5.K_2O+xH_2O$, and tyuyamunite, $2UO_3.V_2O_5.CaO+xH_2O$.[1] Is radioactive and is used as a source of radium.

Arizona, Colorado, Pennsylvania, Utah.

Cassiterite. Tin oxide, SnO_2. Contains 79 per cent tin. The mineral from which practically all tin is obtained.

California, Colorado, Connecticut, Georgia, Idaho, Maine, New Hampshire, North Carolina, South Carolina, South Dakota, Texas, Virginia, Washington, Wyoming.

Catlinite, Indian pipestone. A red clay found in southwestern Minnesota and formerly used by the Indians for making pipes.

Minnesota.

Celestite. Strontium sulphate, $SrO.SO_3$.

Arizona, Arkansas, California, Ohio, Texas.

Cement rock. An argillaceous limestone used in the manufacture of natural hydraulic cement. Contains lime, silica, and alumina in varying proportions, and usually more or less magnesia.

Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming.

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[1] Unpublished work of W. F. Hillebrand.

Cerargyrite, Horn silver. Silver chloride, $AgCl$. Contains 75 per cent silver.
Arizona, California, Colorado, Idaho, Maine, Montana, Nevada, New Mexico, South Dakota, Utah, Washington, Wyoming.

Cerusite. Lead carbonate, $PbO.CO_2$. Contains 77.5 per cent lead.
Arizona, Arkansas, Colorado, Connecticut, Idaho, Illinois, Iowa, Kansas, Missouri, Montana, Nevada, New Mexico, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, South Dakota, Tennessee, Utah, Virginia, Washington, Wisconsin, Wyoming.

Cervantite. An orthorhombic antimony oxide, Sb_2O_4. Infusible before the blowpipe.
Idaho, New Mexico.

Chalcanthite, Blue vitriol, Copper sulphate. A hydrous copper sulphate, $CuO.SO_3+5H_2O$.
Arizona, California, Colorado, Idaho, Montana, Nevada, North Carolina, Tennessee.

Chalcedony. A transparent or more generally translucent cryptocrystalline quartz. Lines or fills cavities in rocks.
Arizona, California, Colorado, Idaho, Iowa, Nebraska, Nevada, Oregon.

Chalcocite, Copper glance. A copper sulphide, Cu_2S. Contains 79.8 per cent copper.
Arizona, California, Colorado, Connecticut, Georgia, Idaho, Maine, Maryland, Minnesota, Missouri, Montana, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, Oregon, Pennsylvania, South Dakota, Tennessee, Texas, Utah, Virginia, Washington, Wisconsin, Wyoming.

Chalcophanite, Hydrofranklinite. A hydrous manganese-zinc oxide $(Mn, Zn)O.2MnO_2.2H_2O$.
New Mexico.

Chalcopyrite, Copper pyrites, Yellow copper ore. A sulphide of copper and iron, $CuFeS_2$. Contains 34.5 per cent copper.
Alabama, Arizona, California, Colorado, Connecticut, Georgia, Idaho, Maine, Massachusetts, Minnesota, Missouri, Montana, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, Wisconsin, Wyoming.

Chalk. A soft, compact, light-colored limestone composed of the delicate skeletons of rhizopods and other marine organisms.
Alabama, Iowa, Nebraska.

Chert, Hornstone. An impure flint or chalcedony with splintery fracture. More brittle than flint.
Alabama, Iowa, Tennessee.

Chiastolite, Macle. A variety of andalusite, aluminum silicate, $Al_2O_3.SiO_2$, in which carbonaceous impurities are arranged in a regular manner along the longer axis of the crystal, in some varieties like the *X* (Greek "chi"), whence the name.
Massachusetts. (Found in many other States but not utilized.)

China clay. *See* Kaolin.

Chlorastrolite. Not a definite mineral but probably a mixture of zeolites. Found as small, light bluish-green pebbles, with finely radiated structure, on Isle Royale, Lake Superior. Used as a gem.
Michigan.

Chromite. A chromate of iron, $FeO.Cr_2O_3$. Contains 68 per cent chromic oxide.
California, Georgia, Maryland, Massachusetts, New York, North Carolina, Oregon, Pennsylvania, Virginia, Wyoming.

Chrysoberyl. A glucinum-aluminum oxide, $GlO.Al_2O_3$, known as cat's-eye when it has a chatoyant effect.

Connecticut, New York.

Chrysocolla. A hydrous copper silicate. Contains theoretically about 36 per cent of copper.

Arizona, California, Colorado, Maryland, Michigan, Montana, Nevada, New Jersey, New Mexico, North Carolina, Oregon, Utah, Virginia, Wyoming.

Chrysolite. *See* Olivine.

Arizona.

Chrysoprase. An apple-green chalcedony, the color of which is due to nickel.

Arizona, California.

Chrysotile. Fibrous serpentine. *See* Asbestos.

Arizona, Maryland, Vermont, Wyoming.

Cinnabar. A vermilion mercury sulphide, HgS, 86 per cent mercury. It is the common ore of mercury and forms hexagonal crystals. *See* Metacinnabarite.

Arizona, California, Colorado, Idaho, Nevada, New Mexico, Oregon, South Dakota, Texas, Utah.

Clay. A natural substance or rock which, when finely ground and mixed with water, forms a pasty, moldable mass that preserves its shape when air dried; the particles soften and coalesce upon being highly heated and form a stony mass upon cooling. Clays vary greatly mineralogically and chemically and consequently in their physical properties. Most of them contain many impurities, but their base is hydrous aluminum silicate.

Every State.

Coal. A carbonaceous substance formed from the remains of vegetation by partial decomposition.

Alabama, Arizona, Arkansas, California, Colorado, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Michigan, Missouri, Montana, Nebraska, Nevada, New Mexico, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Washington, West Virginia, Wyoming.

Cobalt. A metallic element, Co, not found native. *See* Cobaltite, Erythrite, Linnæite, Smaltite.

Colorado, Idaho, Missouri, Nevada, South Carolina, Tennessee, Washington, Wyoming.

Cobalt bloom. *See* Erythrite.

Cobalt pyrites. *See* Linnæite.

Cobaltite, Cobalt glance. A sulpharsenide of cobalt, $CoAsS$. Contains 35.5 per cent of cobalt.

Oregon.

Coke. Coal from which the volatile constituents have been driven off by heat, so that the fixed carbon and the ash are fused together. Commonly artificial, but natural coke is also known.

New Mexico, Virginia.

Colemanite. A hydrous borate of calcium, $2CaO.3B_2O_3.5H_2O$. The commonest source of borax in the United States.

California, Oregon.

Columbite. A variable columbate and tantalate of iron and manganese containing preponderant columbium and grading into tantalite, in which tantalum preponderates.

Colorado, Connecticut, Maine, North Carolina, South Dakota, Virginia.

Copper. An element, Cu. Sometimes found as a native metal. *See also* Azurite, Azurmalachite, Beaverite, Bornite, Brochantite, Chalcanthite, Chalcocite, Chalcopyrite, Chrysocolla, Covellite, Cuprite, Enargite, Famatinite, Freibergite, Goldfieldite, Linarite, Malachite, Melaconite, Stromeyerite, Tennantite, Tenorite, Tetrahedrite.

Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Georgia, Idaho, Maine, Michigan, Minnesota, Missouri, Montana, Nevada, New Jersey, New Mexico, New York, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Utah, Virginia, Washington, Wyoming.

Copper glance. *See* Chalcocite.

Copper pyrites. *See* Chalcopyrite.

Copper sulphate. *See* Chalcanthite.

Coquina. A porous limestone composed of fragments of marine shells.

Florida.

Cordierite, Iolite, Water sapphire. A magnesium-iron-aluminum silicate. Sometimes used as a gem.

Colorado, Connecticut.

Coronadite. A manganate of lead and manganese, $(Mn,Pb)Mn_3O_7$. Resembles psilomelane in general aspect.

Arizona.

Corundum. Aluminum oxide, Al_2O_3. The colored and the clear varieties form the gems, sapphire, ruby, oriental emerald, and oriental topaz; the granular impure variety is known as emery.

Alabama, California, Colorado, Connecticut, Delaware, Georgia, Idaho, Massachusetts, Montana, Nevada, New York, North Carolina, Oregon, Pennsylvania, South Carolina, Virginia, Wyoming.

Cosalite. A sulphide of lead and bismuth, $Pb_2Bi_2S_5$. Contains 42 per cent bismuth.

Colorado, Utah, Washington.

Cotton ball. *See* Ulexite.

Covellite. An indigo-blue copper sulphide, CuS. Contains 66.4 per cent copper.

Alabama, Arizona, Colorado, Georgia, Idaho, Montana, Nevada, South Carolina, Utah, Wyoming.

Crocoite. Lead chromate, $PbO.CrO_3$. Contains 68.9 per cent PbO and 31.1 per cent CrO_3.

Arizona.

Cryolite. A fluoride of sodium and aluminum, $3NaF.AlF_3$.

Colorado.

Cuprite. Native red copper oxide, Cu_2O. Contains 88.8 per cent copper.

Arizona, California, Colorado, Connecticut, Idaho, Missouri, Montana, Nevada, New Jersey, New Mexico, North Carolina, Oregon, Pennsylvania, Tennessee, South Dakota, Utah, Virginia, Wyoming.

Cyanite, Disthene. Identical in chemical composition with andalusite and sillimanite, $Al_2O_3.SiO_2$, but differing in crystal form. Generally in flat-bladed pieces. Sometimes used as a gem.

Delaware, Massachusetts, North Carolina.

Cyrtolite. A yellowish to brownish mineral containing zirconia, yttria, ceria, and other rare earths. Found in pegmatites.

New York, North Carolina, Texas.

Dark ruby silver. *See* Pyrargyrite.

Datolite. A hydrous silicate of boron and calcium, $H_2O.2CaO.B_2O_3.2SiO_2$. Used as a gem.

Michigan.

Descloizite. A vanadate of lead and zinc, found only in the oxidized parts of veins.
Arizona, New Mexico.

Diabase. A basic igneous rock usually occurring in dikes or intrusive sheets, and composed essentially of plagioclase feldspar and augite with small quantities of magnetite and apatite. The plagioclase forms lath-shaped crystals lying in all directions among the dark irregular augite grains, giving rise to the peculiar diabasic or ophitic texture, which is a distinctive feature in the coarser-grained occurrences.
Connecticut, Maryland, Massachusetts, New Jersey, New York, Virginia.

Diamond. A very hard, native, crystallized form of carbon, C. When pure and clear it is used as a gem.
Arkansas, California, Georgia, Indiana, Michigan, North Carolina, Virginia.

Diatomaceous earth. *See* Infusorial earth.

Diopside. A calcium-magnesium silicate, $CaMg(SiO_3)_2$.
California, Georgia.

Diorite. A granitoid rock composed essentially of hornblende and feldspar which is mostly or wholly plagioclase, with accessory biotite and (or) augite. Minute grains of magnetite and titanite may be visible. Quartz may be present in considerable amount, in which case the rock is called quartz diorite.
Quarried for crushed rock in the District of Columbia, Virginia, and many other States.

Disthene. *See* Cyanite.

Dolomite. (*a*) A carbonate of calcium and magnesium, $(Ca,Mg)CO_3$. (*b*) A rock composed mainly of the mineral dolomite.
Alabama, Connecticut, Indiana, Iowa, Kentucky, Maryland, Rhode Island, Tennessee, Virginia.

Dufrenite. A hydrous iron phosphate. Contains approximately 27.5 per cent P_2O_5, 62 per cent Fe_2O_3, and 10.5 per cent H_2O. Exact composition doubtful.
Virginia.

Dufrenoysite. A sulpharsenide of lead, $Pb_2As_2S_5$.
Arizona, Idaho.

Dyscrasite. A variable silver antimonide including Ag_3Sb.
Arizona.

Eglestonite. A mercury oxychloride, Hg_4Cl_2O.
Texas.

Elaterite. A massive amorphous dark-brown hydrocarbon ranging from soft and elastic to hard and brittle. It melts in a candle flame without decrepitation, has a conchoidal fracture and gives a brown streak. *See also* Wurtzilite.
Utah.

Electrum. A natural alloy of gold and silver containing approximately 40 per cent of silver.
California, Nevada.

Embolite. A chlorobromide of silver, $Ag(Cl,Br)$.
Arizona, Colorado, New Mexico.

Emerald. A variety of beryl (which see). Used as a gem.
North Carolina.

Emery. An impure form of corundum (Al_2O_3) used as an abrasive. *See* Corundum.
Massachusetts, New York, Virginia.

Enargite. A copper sulpharsenide, Cu_3AsS_4. Contains 48.4 per cent copper.
Colorado, Montana, Nevada, South Carolina, South Dakota, Utah.

Endlichite. *See* Vanadinite.
New Mexico.

Epidote. A basic orthosilicate of calcium, aluminum, and iron, $H_2O.4CaO.3(Al,Fe)_2O_3.6SiO_2$.

Colorado, Maine.

Epsomite. A hydrous magnesium sulphate, $MgSO_4+7H_2O$.

New Mexico, Tennessee, Wyoming.

Erubescite. *See* Bornite.

Erythrite, Cobalt bloom. A hydrous cobalt arsenate, $Co_3As_2O_8.8H_2O$. Found in the oxidized parts of cobalt and arsenic-bearing veins.

California, Colorado, Idaho, Nevada.

Essonite. A cinnamon-colored variety of garnet; called hyacinth when used as a gem, though the term more properly belongs to zircon.

Maine, New Hampshire.

Famatinite. A copper-antimony sulphide, $3Cu_2S.Sb_2S_5$. Contains 43.3 per cent copper.

Nevada.

Feather ore. *See* Jamesonite.

Feldspar. A general name for a group of abundant rock-forming minerals, the names and compositions of which are as follows:

Orthoclase, a monoclinic potassium-aluminum silicate, $K_2O.Al_2O_3.6SiO_2$; varieties are known as adularia and sanidine.

Microcline, a triclinic variety of the same composition as orthoclase.

Anorthoclase, a triclinic feldspar containing both sodium and potassium.

Plagioclase feldspars are a subgroup of triclinic minerals at one end of which is albite, a sodium-aluminum silicate, $Na_2O.Al_2O_3.6SiO_2$; and at the other end anorthite, a calcium-aluminum silicate, $CaO.Al_2O_3.2SiO_2$. Mixtures of these two molecules, which may be represented by Ab and An, respectively, form:

Oligoclase, Ab_6An_1 to Ab_3An_1.
Andesine, Ab_3An_1 to Ab_1An_1.
Labradorite, Ab_1An_1 to Ab_1An_3.
Bytownite, Ab_1An_3 to Ab_1An_6.

Celsian is similar to anorthite, but contains barium in place of calcium, $BaO.Al_2O_3.2SiO_2$.

Hyalophane is a monoclinic form containing barium and calcium.

Feldspar is found in practically all igneous rocks.

Alabama, California, Connecticut, Delaware, Maine, Maryland, Massachusetts, Minnesota, Missouri, New York, North Carolina, Pennsylvania, South Carolina, Vermont, Virginia, Wisconsin.

Ferberite. An iron tungstate, $FeWO_4$. Applied to the wolframites which carry little or no manganese. Ferberite contains 76.3 per cent tungsten trioxide, WO_3.

Colorado, South Dakota.

Fergusonite. A metacolumbate and tantalate of yttrium, with erbium, cerium, uranium, etc. Found in pegmatites.

Texas, Virginia.

Flagstone. A rock which may be cleft into large slabs suitable for sidewalks.

Alabama, Connecticut, Illinois, Indiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Tennessee, Vermont, Virginia, Wyoming.

Flexible sandstone. *See* Itacolumite.

Flint. A rather loose term, used in the United States for a dense fine-grained form of silica which is very tough and breaks with a conchoidal fracture and cutting edges. Of various colors, white, yellow, gray, and black. *See* Chert.

Maryland, Nebraska, Wisconsin.

Fluorspar, Fluorite. A calcium fluoride, CaF_2. Color commonly purple, green, or white.

Arizona, California, Colorado, Connecticut, Illinois, Kentucky, Maryland, Massachusetts, Missouri, New Hampshire, New Jersey, New Mexico, New York, Pennsylvania, South Dakota, Tennessee, Texas, Utah, Virginia, Washington, West Virginia.

Fool's gold. *See* Pyrite.

Fossil wax. *See* Ozokerite.

Franklinite. An iron-manganese-zinc oxide $(Fe,Zn,Mn)O.(Fe,Mn)_2O_3$.

New Jersey.

Freestone. *See* Sandstone.

Freibergite. A silver-rich tetrahedrite. *See* Tetrahedrite.

Idaho, Nevada.

Freieslebenite. A lead-silver sulphantimonide, approximately $5\,(Pb,Ag_2)\,S.2Sb_2S_3$. Contains 24.5 per cent silver.

Arizona, Colorado.

French chalk. *See* Talc.

Fuller's earth. An imperfectly understood clay relatively high in magnesia and possessing the property of decolorizing oils and fats by retaining the coloring matter. It may or may not be plastic.

Arkansas, Colorado, Florida, Georgia, Massachusetts, South Carolina, South Dakota, Texas.

Gabbro. A finely to coarsely crystalline igneous rock composed mainly of lime-soda feldspar (labradorite or anorthite), pyroxene, and frequently olivine. Magnetite or ilmenite, or both, and apatite are accessory minerals. It is generally dark colored.

California, Maryland, South Dakota, Virginia.

Gadolinite. A complex silicate of glucinum, iron, and the yttrium and cerium rare-earth metals. Occurs in pegmatites.

Arizona, Colorado, Texas.

Galena. Lead sulphide, PbS. Contains 86.6 per cent lead.

Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Georgia, Idaho, Illinois, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Minnesota, Missouri, Montana, Nevada, New Hampshire, New Mexico, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, Wisconsin, Wyoming.

Ganister. A highly refractory siliceous sedimentary rock used for furnace linings.

Pennsylvania.

Garnet. A group of silicate minerals including several species with related chemical structure commonly crystallized in dodecahedrons or trapezohedrons of the isometric (cubic) system. Garnets are not always pure but may contain the molecules of two species giving rise to intermediate types, as the gem rhodolite. Common varieties are:

Almandite, iron-aluminum garnet (abrasive and gem, precious garnet).

Andradite, lime-iron garnet.

Essonite, gem variety of grossularite.

Grossularite, lime-aluminum garnet.

Pyrope, magnesia-aluminum garnet; gems—"Arizona ruby," "Cape ruby," etc.

Rhodolite, isomorphous mixture of 2 molecules of pyrope and 1 molecule of almandite.

Spessartite, manganese-aluminum garnet; used as a gem, sometimes called hyacinth.

Arizona, California, Colorado, Connecticut, Georgia, Idaho, Kentucky, Massachusetts, Montana, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Oregon, Pennsylvania, Virginia.

Garnierite. A hydrous nickel-magnesium silicate allied to genthite.

Oregon.

Genthite. A hydrous nickel-magnesium silicate, theoretically $2NiO.2MgO.3SiO_2.6H_2O$, but the nickel content is variable.

Georgia, Oregon.

Geode. A hollow nodule or concretion, the cavity of which is lined with crystals.

Illinois, Iowa.

Giant granite. *See* Pegmatite.

Gilsonite, Uintaite. A brilliant black, very brittle variety of asphalt having a marked conchoidal fracture and a brown streak. Upon exposure to air readily breaks down into a brown powder. Decrepitates but fuses easily in a candle flame, and is soluble in carbon disulphide (CS_2), alcohol, and turpentine.

Utah.

Glauber salt. *See* Mirabilite.

Glauberite. Sodium-calcium sulphate, $Na_2SO_4.CaSO_4$.

Arizona, New Mexico.

Glauconite, Greensand. Essentially a hydrous silicate of iron and potassium, but the material is usually a mixture and consequently varies much in composition. The potash ranges from 2.2 to 7.9 per cent. *See* Marl.

Gneiss. A banded metamorphic rock with a more or less well developed cleavage, but without the fissility of schist.

Connecticut, Delaware, District of Columbia, Georgia, Maryland, Massachusetts, Minnesota, New Jersey, North Carolina, Virginia.

Gold. An element, Au. Generally found as native metal. *See also* Amalgam, Calaverite, Electrum, Krennerite, Nagyagite, Petzite, Sylvanite.

Alabama, Arizona, California, Colorado, Georgia, Idaho, Indiana, Iowa, Maine, Maryland, Michigan, Minnesota, Montana, Nebraska, Nevada, New Hampshire, New Mexico, North Carolina, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, Wyoming.

Goldfieldite. A sulphantimonide of copper in which part of the antimony is replaced by arsenic and bismuth and part of the sulphur by tellurium.

Nevada.

Grahamite. A hydrocarbon resembling albertite in its jet-black luster. Is soluble in carbon disulphide and chloroform but not in alcohol, and is fusible. Occurs in veinlike masses. Specific gravity 1.145. Has conchoidal fracture and is brittle.

Colorado, Oklahoma, West Virginia.

Granite. A granular igneous rock composed essentially of quartz, orthoclase or microcline, and mica. Commonly a part of the feldspar is plagioclase. The mica may be either biotite or muscovite or both. Hornblende is a common, and augite an uncommon, component. Apatite, zircon, and magnetite are always present, generally as very small individuals. Commercially, almost all compact igneous rocks are called granite as distinguished from slate, sandstone, and marble.

Alabama, Arizona, California, Colorado, Connecticut, Delaware, District of Columbia, Georgia, Idaho, Iowa, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, New Hampshire, New Jersey, New York, North Carolina, North Dakota, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, Wisconsin, Wyoming.

Granodiorite. An igneous rock intermediate between granite and quartz diorite. Found in the Pacific coast, Rocky Mountain, and Eastern States.

Graphite. A soft, steel-gray to black, more or less impure, native form of carbon.
Alabama, Arizona, California, Colorado, Connecticut, Georgia, Maine, Massachusetts, Michigan, Montana, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, Wisconsin, Wyoming.

Gravel. Small stones and pebbles or a mixture of sand and small stones; more specifically, fragments of rock worn by the action of air and water, larger and coarser than sand. Gravel occurs and is used in every State.

See Gravel in Iowa, Kentucky, and Louisiana, and Sand and gravel in other States.

Gray antimony. *See* Stibnite.

Gray copper ore. *See* Tennantite, Tetrahedrite.

Gray manganese ore. *See* Manganite.

Green lead ore. *See* Pyromorphite.

Greenockite. Cadmium sulphide, CdS. Contains 77.7 per cent cadmium. Greenockite occurs as a secondary mineral in zinc deposits in various parts of the United States, but not as a commercial deposit at any place. The majority of sphalerite deposits are cadmiferous, and cadmium in commercial quantity is obtained as a by-product in smelting these ores at certain plants.
Arkansas, Colorado, Missouri, Pennsylvania.

Greensand. *See* Glauconite.

Greensand marl. Sands or marl containing glauconite. *See* Marl.

Grindstone. A tough sandstone of fine and even grain, composed almost entirely of quartz, mostly in angular grains. It must have sufficient cementing material to hold the grains together but not enough to fill the pores and cause the surface to wear smooth.
Colorado, Connecticut, Indiana, Massachusetts, Michigan, Missouri, Montana, Ohio, South Dakota, West Virginia, Wyoming.

Gypsite. *See* Gypsum.

Gypsum. Hydrous calcium sulphate, $CaSO_4+2H_2O$. Contains 32.5 per cent lime, 46.6 per cent sulphur trioxide, and 20.9 per cent water. Alabaster is a fine-grained compact variety, white, shaded, or tinted.

Gypsite is an incoherent mass of very small gypsum crystals or particles, and has a soft, earthy appearance; contains various impurities, generally silica and clay.

Satin spar is a fine fibrous variety which has a pearly, opalescent appearance.

Selenite is a variety which occurs in distinct crystals or in broad folia. Some crystals are 3 or 4 feet long and clear throughout.

Alabama, Arizona, Arkansas, California, Colorado, Florida, Iowa, Kansas, Louisiana, Michigan, Mississippi, Montana, Nevada, New Mexico, New York, Ohio, Oklahoma, Oregon, South Dakota, Tennessee, Texas, Utah, Virginia, Wyoming.

Halite, Rock salt. Sodium chloride, NaCl. *See* Salt.

Halloysite. A claylike aluminum silicate resembling kaolinite but amorphous and containing a larger but uncertain quantity of water, $2H_2O.Al_2O_3.2SiO_2+Aq$.
Alabama, Georgia.

Halotrichite. Hydrous sulphate of iron and aluminum, $FeSO_4.Al_2(SO_4)_3+24H_2O$.
New Mexico.

Hard coal. *See* Anthracite.

Heavy spar. *See* Barite.

Hematite, Specular iron, Red iron ore. Oxide of iron, Fe_2O_3. Contains 70 per cent iron.

Alabama, Arizona, California, Colorado, Georgia, Idaho, Indiana, Iowa, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Montana, Nevada, New Jersey, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming.

Hessite. Silver telluride, Ag_2Te. Contains 63.3 per cent silver.

Colorado, Oregon.

Hiddenite. An emerald-green spodumene. Used as a gem. *See* Spodumene.

North Carolina.

Hinsdalite. A mineral related to alunite, but with replacements as indicated in the following formula: $2\ PbO.3Al_2O_3.2SO_3.P_2O_5.6H_2O$.

Colorado.

Horn silver. *See* Cerargyrite.

Hornstone. *See* Chert.

Hübnerite. Nearly pure manganese tungstate, $MnWO_4$. When pure it contains 76.6 per cent tungsten trioxide, WO_3.

Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, South Dakota, Utah, Washington.

Hyalite. A variety of opal (hydrous silica) which occurs in clear globular or botryoidal forms resembling drops of melted glass.

Georgia, Kansas.

Hydrofranklinite. *See* Chalcophanite.

Hydrozincite, Zinc bloom. A basic zinc carbonate, exact composition uncertain, perhaps $3ZnO.CO_2.2H_2O$.

Arkansas, Kansas, New Mexico.

Ilmenite, Menaccanite. Iron-titanium oxide, $FeTiO_3$. Contains 36.8 per cent iron and 31.6 per cent titanium (52.7 per cent TiO_2).

South Carolina, Texas, Virginia, Wyoming.

Impsonite. An asphalt much like albertite but almost insoluble in turpentine.

Oklahoma.

Indian pipestone. *See* Catlinite.

Infusorial earth, Diatomaceous earth, Tripolite. An earthy substance or soft rock composed of the siliceous skeletons of small aquatic plants called diatoms.

Alabama, California, Colorado, Delaware, Florida, Maryland, Maine, Massachusetts, Nebraska, Nevada, New Hampshire, New York, Oregon, South Carolina, South Dakota, Utah, Vermont, Virginia, Washington.

Iodyrite. Silver iodide, AgI. Contains 46 per cent silver.

New Mexico.

Iolite. *See* Cordierite.

Iridosmine. A natural alloy of iridium and osmium. Analyses show 43 to 77 per cent of iridium, 17 to 49 per cent osmium, and a little rhodium, ruthenium, platinum, iron, and copper.

Washington.

Iron. An element, Fe. Rarely found native. *See* Brown iron ore, Hematite, Ilmenite, Limonite, Magnetite, Marcasite, Pisanite, Pyrite, Pyrrhotite, Siderite, Specularite.

Iron pyrites. *See* Pyrite.

Itacolumite, Flexible sandstone. A variety of metamorphosed sandstone, slabs of which will bend noticeably without breaking.

Georgia.

Jack. *See* Sphalerite.

Jade, Jadeite, Nephrite. A hard and extremely tough material of varying composition, greenish white to deep green in color, used in making carved ornaments. Part of the so-called jade is jadeite, a variety of pyroxene, essentially a metasilicate of sodium and aluminum. Part is nephrite, a variety of amphibole, and essentially a metasilicate of iron, lime, and magnesium; and part is a variety of saussurite, which is commonly a complex alteration product of plagioclase feldspar. Williamsite, a variety of serpentine, is sometimes mistaken for jade.

Massachusetts.

Jamesonite, Feather ore. A sulphide of lead and antimony, $Pb_2Sb_2S_5$.

Arizona, Nevada, South Dakota.

Jasper. Red, brown, yellow, green, impure, slightly translucent cryptocrystalline quartz with a dull fracture.

Arizona, California, Massachusetts, South Dakota, Texas.

Jaspilite. A term used around Lake Superior for the jasper associated with the iron ores. It is made up of bands of bright red jasper alternating with bands of black, commonly specular hematite.

Michigan.

Jet. A dense black lignite, taking a good polish. Sometimes used for jewelry.

Colorado.

Josephinite. A natural iron-nickel alloy, Fe_2Ni_5.

Oregon.

Kalinite, Potash alum. Hydrous aluminum-potassium sulphate, $K_2SO_4.Al_2(SO_4)_3+24H_2O$.

California, Nevada.

Kaolin, China clay, Porcelain clay. A clay, mainly hydrous aluminum silicate, from which porcelain may be made.

Alabama, Arizona, Arkansas, California, Colorado, Delaware, Georgia, Indiana, Minnesota, Missouri, Nevada, Pennsylvania, Virginia, Wisconsin, Wyoming.

Kleinite. Mercury ammonium chloride. Formula uncertain.

Texas.

Krennerite. Orthorhombic telluride of gold and silver. Composition variable, $(Au,Ag)Te_2$. At Cripple Creek analysis gives gold 43.86 per cent, silver 0.46 per cent, tellurium 55.68 per cent.

Colorado.

Kunzite. A lilac-colored or pink spodumene. Used as a gem.

California, Maine.

Labradorite. A lime-soda feldspar. *See* Feldspar and Moonstone.

New York.

Lapis lazuli. A translucent, rich berlin-blue, azure-blue, violet-blue, or greenish-blue stone used for ornament. It is a mixture of lazurite, haüynite, and other blue minerals.

California.

Lazulite. A hydrous aluminum phosphate with varying proportions of iron and magnesium, $(Fe,Mg)O.Al_2O_3.P_2O_5.H_2O$. Azure blue in color, usually in pyramidal crystals; also massive. Used as an ornamental stone.

California, Georgia, Nevada.

Lava. A rock that has reached the surface of the earth while molten.

Lead. A heavy metallic element, Pb. Rarely found native. *See also* Altaite, Anglesite, Brongniardite, Cerusite, Crocoite, Dufrenoysite, Galena, Jamesonite, Leadhillite, Linarite, Massicot, Mimetite, Minium, Plumbojarosite, Pyromorphite.

Alabama, Arizona, California, Colorado, Connecticut, Georgia, Idaho, Illinois, Iowa, Kansas, Maine, Massachusetts, Missouri, Montana, Nevada, New Mexico, New York, Pennsylvania, South Dakota, Tennessee, Utah, Virginia, Wisconsin, Wyoming.

Leadhillite. Sulphato-carbonate of lead, perhaps $4PbO.SO_3.2CO_2.H_2O$.

Arizona.

Lepidolite. A light-colored (pearly, rose-red, violet-gray, lilac, yellowish) lithium-bearing mica. Contains from 3.9 to 5.9 per cent lithia, Li_2O.

California, Connecticut, Maine, South Dakota.

Light ruby silver. *See* Proustite.

Lignite. A brownish-black coal in which the alteration of vegetable material has proceeded farther than in peat but not so far as in subbituminous coal.

Arkansas, Florida, Idaho, Kansas, Kentucky, Louisiana, Massachusetts, Mississippi, Minnesota, Montana, North Carolina, North Dakota, South Carolina, South Dakota, Tennessee, Texas.

Limestone. A rock composed mainly of calcium carbonate.

All parts of the United States except District of Columbia and North Dakota.

Limonite. *See* Brown iron ore.

Linarite. A basic sulphate of lead and copper, $PbO.CuO.SO_3.H_2O$.

California.

Linnæite, Cobalt pyrites. A sulphide of cobalt, Co_3S_4. A part of the cobalt is nearly always replaced by nickel and to a less extent by iron and copper.

Maryland, Missouri.

Lithographic stone. A fine-grained homogeneous limestone suitable for etching.

Alabama, Iowa, Kentucky, Nebraska, South Dakota, Tennessee.

Mackintoshite. A hydrous uranium-thorium silicate.

Texas.

Macle. *See* Chiastolite.

Magnesite. Magnesium carbonate, $MgO.CO_2$.

California, New Jersey, New York.

Magnetite, Magnetic iron ore. The magnetic iron oxide, $FeO.Fe_2O_3$. Contains 72.4 per cent iron.

Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Georgia, Idaho, Maine, Maryland, Massachusetts, Michigan, Minnesota, Montana, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Utah, Vermont, Virginia, Wisconsin, Wyoming.

Magnetic pyrites. *See* Pyrrhotite.

Malachite. Green basic copper carbonate, $2CuO.CO_2.H_2O$. Contains 40.3 per cent copper.

Arizona, California, Colorado, Connecticut, Florida, Georgia, Idaho, Maryland, Missouri, Montana, Nevada, New Hampshire, New Jersey, New Mexico, North Carolina, Oklahoma, Oregon, Pennsylvania, South Dakota, Tennessee, Utah, Vermont, Virginia, Washington, Wisconsin, Wyoming.

Manganese. A metallic element, Mn. Occurs abundantly in nature, chiefly as oxides. *See* Alabandite, Braunite, Chalcophanite, Coronadite, Manganite, Psilomelane, Pyrolusite, Rhodochrosite, Rhodonite, Tephroite, Wad.

Arizona, Arkansas, California, Colorado, Georgia, Maryland, Michigan, Missouri, Montana, Nevada, New Mexico, North Carolina, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Utah, Vermont, Virginia, West Virginia, Wisconsin, Wyoming.

Manganese hydrate. *See* Psilomelane.

Manganite, Gray manganese ore. A hydrated manganese oxide, $Mn_2O_3.H_2O$.

Alabama, Georgia, New Mexico.

Marble. Crystalline granular limestone or dolomite, generally susceptible of a high polish.

Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Georgia, Idaho, Iowa, Kentucky, Maryland, Massachusetts, Michigan, Missouri, Nevada, New Jersey, New Mexico, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, Wyoming.

Marcasite, White iron pyrite. Orthorhombic iron disulphide, FeS_2. Contains 46.6 per cent iron.

Colorado, Idaho, Iowa, Kansas, Michigan, Missouri, Montana, Oklahoma, Oregon, Wisconsin.

Marl. A soft earthy deposit of calcium carbonate, containing more or less clay and sand.

Alabama, Arkansas, Delaware, Florida, Georgia, Indiana, Iowa, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Mississippi, Minnesota, New Hampshire, New Jersey, New York, North Carolina, Ohio, Tennessee, South Carolina, Vermont, Virginia, Wyoming.

Massicot. Lead monoxide, PbO. Contains 92.8 per cent lead.

Colorado, Idaho, Nevada, Virginia.

Meerschaum, Sepiolite. A tough, compact hydrous magnesium silicate.

California, New Mexico.

Melaconite. Black copper oxide, CuO. Contains 79.8 per cent copper. The name given to an earthy, black, massive variety of tenorite.

Alabama, Arizona, Colorado, Idaho, North Carolina, Pennsylvania, Tennessee, Virginia, Washington, Wyoming.

Menaccanite. *See* Ilmenite.

New Jersey, New York, North Carolina.

Mercury, Quicksilver. An element sometimes found native, Hg. *See also* Amalgam, Cinnabar, Eglestonite, Kleinite, Metacinnabarite, Montroydite, Terlinguaite, Tiemmanite.

California.

Metacinnabarite. Composition same as cinnabar, but black in color, and crystallizing in isometric forms (tetrahedral). *See* Cinnabar.

California.

Mexican onyx. *See* Onyx marble.

Mica. A hydrous silicate having a very fine basal cleavage which renders it capable of being split into thin tough transparent plates. The most common varieties are muscovite and biotite. Phlogopite and lepidolite are prominent locally.

Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Georgia, Idaho, Maine, Maryland, Massachusetts, Minnesota, Nevada, New Hampshire, New Mexico, New York, North Carolina, South Carolina, South Dakota, Texas, Vermont, Virginia, West Virginia, Wyoming.

Microlite. Essentially a calcium pyrotantalate. Contains also small quantities of columbium, fluorine, tungsten, and other bases. Used as a gem.

Virginia.

Millerite. Nickel sulphide, NiS. Contains 64.1 per cent nickel.

California, Pennsylvania.

Millstone. A hard tough stone used for grinding cereals, cement rocks, and other materials. Usually a coarse-grained sandstone or fine quartz conglomerate.

Alabama, Georgia, Mississippi, New York, North Carolina, Pennsylvania, Virginia.

Mimetite. Lead chlorarsenate, $3Pb_3As_2O_8.PbCl_2$.

California, Colorado, Nevada.

Mineral oil. *See* Petroleum.

Mineral paint. Minerals used as pigment, including the ochers, iron oxides, barite, etc. *See also* Ocher, Sienna, Umber.

Alabama, Arizona, California, Connecticut, Florida, Georgia, Indiana, Iowa, Kentucky, Massachusetts, Minnesota, Missouri, New York, Oregon, Pennsyl[illegible]nia, Tennessee, Washington, Wyoming.

Mineral pitch. *See* Asphalt.

Mineral wax. *See* Ozokerite.

Minium. Red oxide of lead, $2PbO.PbO_2$. Contains 90.6 per cent lead.
Colorado.

Mirabilite, Glauber salt. Hydrous sodium sulphate, $Na_2SO_4+10H_2O$.
Arizona, Oregon, Wyoming.

Mispickel. *See* Arsenopyrite.

Molybdenite. Sulphide of molybdenum, MoS_2. Contains 60 per cent molybdenum.
Arizona, California, Colorado, Connecticut, Maine, Montana, Nevada, New Jersey, New Mexico, New York, Rhode Island, South Carolina, Utah, Washington.

Molybdenum. A metallic element, Mo, of wide but not abundant distribution. *See* Molybdenite and Wulfenite.

Monazite. Phosphate of the cerium metals (cerium, didymium, lanthanum) and other rare-earth metals, including thorium, which alone gives it commercial value. Some varieties carry no thorium, but others carry as much as 18 per cent thorium oxide.
Colorado, Connecticut, Idaho, Montana, Nevada, New Mexico, North Carolina, Oregon, South Carolina, Utah, Virginia, Washington, Wyoming.

Montroydite. Oxide of mercury, HgO.
Texas.

Moonstone. A variety of feldspar, commonly transparent or translucent orthoclase, albite, or labradorite, which exhibits a delicate pearly opalescent play of colors.
Pennsylvania, Virginia.

Mountain brown ore. A local name for limonite or brown iron ore. Applied in Virginia to the low-grade siliceous variety, which commonly occurs in hard lumps and which is found on the mountain slopes at or near the contact of the Cambrian shale and sandstone with the Cambro-Ordovician limestone. *See* Valley brown ore.
Virginia.

Muscovite. Potash-bearing white mica, $H_2KAl_3(SiO_4)_3$. *See* Mica.
Alabama, Arizona, Arkansas, New York, Wyoming.

Nagyagite. A sulphotelluride of lead, gold, and antimony, possibly $Au_2Pb_{14}Sb_3Te_7S_{17}$. The gold content ranges from 5.8 to 12.8 per cent, the silver from 8.1 to 10.8 per cent.
North Carolina.

Native paraffin. *See* Ozokerite.

Natron. Hydrous sodium carbonate, $Na_2CO_3.+10H_2O$.
Oregon, Wyoming.

Natural gas. A mixture of gaseous hydrocarbons found in nature; in many places connected with deposits of petroleum, to which the gaseous compounds are closely related.
Alabama, Arkansas, California, Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Michigan, Missouri, New Mexico, New York, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, South Dakota, Tennessee, Texas, Utah, West Virginia, Wyoming.

Nelsonite. A dike rock composed essentially of ilmenite or rutile and apatite.
Virginia.

Nephrite. *See* Jade.

Niccolite, Arsenical nickel. Arsenide of nickel, $NiAs$. Contains 43.9 per cent nickel.
Colorado.

Nicholsonite. A variety of aragonite (the orthorhombic carbonate of lime, $CaCO_3$) containing from less than 1 per cent up to 10 per cent of zinc.
Colorado.

Nickel. A metallic element, Ni. *See also* Annabergite, Garnierite, Genthite, Josephinite, Millerite, Niccolite, Pyrrhotite, Zaratite.

California, Georgia, Idaho, Minnesota, Missouri, Nevada, Oregon, South Carolina, Virginia, Washington, Wyoming.

Nigrite. A name given to a variety of asphalt mined at Soldier Summit, Utah, but whose composition is imperfectly understood.

Utah.

Niter, Saltpeter. Potassium nitrate, KNO_3.

Alabama, Arkansas, California, Indiana, Oregon, Tennessee, Utah, Virginia, West Virginia, Wyoming.

Nivenite. A variety of uraninite high in uranium and carrying 10 per cent or more of the yttrium earths and 6.7 to 7.6 per cent thoria. It is wholly soluble in dilute sulphuric acid. *See* Uraninite.

Texas.

Novaculite. An extremely fine grained quartzose sedimentary rock.

Arkansas, Georgia, Massachusetts, North Carolina, Oklahoma, Tennessee.

Obsidian, Volcanic glass. Extrusive igneous rocks which have cooled either without crystallization or with only partial crystallization.

Arizona, California, Nevada, Utah.

Ocher. A metallic oxide occurring in an earthy or pulverulent form. Commercially ocher is used to mean the yellow, red, and brown earthy iron oxides.

Alabama, California, Delaware, Georgia, Indiana, Iowa, Kentucky, Maine, Maryland, Mississippi, Missouri, Nebraska, Nevada, New Hampshire, New Jersey, Pennsylvania, South Dakota, Vermont, Virginia, Washington, West Virginia, Wisconsin.

Oilstone. A fine-grained whetstone on which oil is used.

Arkansas, Georgia, Indiana, Ohio.

Olivine, Chrysolite, Peridot. An orthosilicate of iron and magnesium, $2(Mg.Fe)O.SiO_2$. Used as a gem.

Arizona.

Onofrite. Sulpho-selenide of mercury, $Hg(S,Se)$. Contains 81 to 82 per cent of mercury.

Onyx. A cryptocrystalline variety of quartz, made up of different colored layers, chiefly white, yellow, black, or red. Not found in commercial quantity in United States.

"Onyx marble" (including Mexican onyx). Calcite somewhat resembling true onyx in appearance and used as an ornamental stone. Is usually formed as stalactites, stalagmites, vein filling, or spring deposits.

Arizona, California, Kentucky, Missouri, New Mexico, Tennessee, Texas, Virginia.

Opal. Hydrous silica, $SiO_2.xH_2O$. When it shows a play of colors, or "opalescence," it becomes the gem stone or precious opal of commerce, known as "fire opal."

Arizona, California, Colorado, Georgia, Nevada, New Mexico, Oregon, Utah, Washington.

Orpiment. Arsenic trisulphide, As_2S_3. Contains 61 per cent arsenic (the element).

Utah.

Orthite. *See* Allanite.

Orthoclase. The monoclinic potash feldspar, $K_2O.Al_2O_3.6SiO_2$. Contains 16.9 per cent potash, K_2O. *See* Feldspar.

Ozokerite, Mineral wax, Fossil wax, Native paraffin. Waxlike hydrocarbon, yellow-brown to green in color; translucent when pure; feels greasy. Streak is light to brown, and specific gravity is slightly less than 1. Soluble in carbon disulphide.

Utah, Wyoming.

Palladium. An element, Pd, one of the platinum metals. Occurs in minute quantities in copper ores and is recovered in electrolytic refineries.

Wyoming.

Peacock copper ore. *See* Bornite, Erubescite.

Peat. Partly decayed vegetable matter which has accumulated in marshes and wet places.

Florida, Illinois, Indiana, Massachusetts, Michigan, Minnesota, Nebraska, New Hampshire, New Jersey, New York, North Carolina, Ohio, Rhode Island, South Carolina, South Dakota, Tennessee, Vermont, Wisconsin.

Pegmatite, Giant granite. An igneous rock, generally coarse grained but usually irregular in texture and composition, composed mainly of silicate minerals of large size, including quartz, feldspar, muscovite, biotite, tourmaline, beryl, lithia minerals, zircon, etc. Some pegmatites carry minerals containing rare earth metals, tin, tungsten, tantalum, uranium, and others.

Pencil stone. *See* Pyrophyllite.

Peridot. *See* Olivine.

Peridotite. A granular rock composed chiefly of olivine and pyroxene with little or no feldspar.

Petroleum, Mineral oil. An oily, inflammable, liquid mixture of numerous hydrocarbons, chiefly of the paraffin series, found in the earth. The petroleums found in different areas vary widely in composition and appearance.

Alabama, California, Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Michigan, Missouri, Montana, New Mexico, New York, Ohio, Oklahoma, Pennsylvania, Tennessee, Texas, Utah, Washington, West Virginia, Wyoming.

Petzite. Telluride of silver and gold, $(Ag,Au)_2Te$. The gold content ranges from 18.2 to 25.6 per cent and the silver from 40.7 to 46.8 per cent.

California, Colorado.

Phenacite. Glucinum orthosilicate, Gl_2SiO_4.

Colorado.

Phosphate rock. A sedimentary rock containing phosphate of lime. The form in which the phosphate of lime occurs is obscure.

Alabama, Arkansas, Florida, Idaho, Kentucky, Montana, South Carolina, Tennessee, Utah, Virginia, Wyoming.

Pisanite. An iron sulphate in which part of the iron is replaced by copper, $(FeCu)SO_4+7H_2O$.

Montana.

Pitchblende. *See* Uraninite.

Colorado, Connecticut, North Carolina.

Platinum. An element, Pt, occurring as a native metal. Practically all platinum is found in the metallic state, though small quantities are obtained from sperrylite (which see) and in the electrolytic refining of copper ores.

Arizona, California, Colorado, Idaho, Maine, Montana, Nevada, North Carolina, Oregon, South Carolina, Utah, Washington, Wyoming.

Plumbojarosite. A hydrous sulphate of lead and iron, $PbFe_6(OH)_{12}(SO_4)_4$.

New Mexico, Utah.

Pollucite. Hydrous cæsium-sodium-aluminum silicate, $H_2O.(Cs,Na)_2O.Al_2O_3.5SiO_2$. Found in pegmatite.

Maine.

Polybasite. Sulphide of silver and antimony, Ag_9SbS_6. If pure, it would contain 75.6 per cent silver, but copper replaces part of the silver; also arsenic replaces antimony.

Arizona, Colorado, Idaho, Montana, Nevada.

Polycrase. A columbate and titanate of yttrium, erbium, cerium, and uranium, with some iron and water.

North Carolina, South Carolina, Texas.

Porcelain clay. *See* Kaolin.

Porphyry. An igneous rock in which relatively large conspicuous crystals (phenocrysts) are set in a finer-grained or glassy groundmass. Porphyries are generally named in accordance with their rock composition (e. g., granite porphyry, trachyte porphyry) or with the character of the phenocrysts, as quartz porphyry. Colloquially the word "porphyry" is used to mean almost any igneous rock, particularly one that is spotted, soft, or light colored.

Oklahoma, Wisconsin. Occurs in many States but is little used.

Potash. The oxide of potassium, K_2O. Not an independent compound, but used as a basis of comparison for all potash minerals and artificial salts. The potash of commerce is derived from the minerals carnallite, kainite, sylvite (not found in the United States), and niter, and also from certain seaweeds and wood ashes. *See also* Alunite, Alunogen, Kalinite, Niter.

Alabama, California, Tennessee, Virginia, West Virginia, Wyoming.

Potash alum. *See* Kalinite.

Priceite. A friable, chalky boron mineral similar to colemanite. *See* Colemanite.

Proustite, Light ruby silver. Silver-arsenic sulphide, $3Ag_2S.As_2S_3$. Contains 65.4 per cent silver.

Arizona, Colorado, Idaho, Montana, Nevada, New Mexico.

Psilomelane, Manganese hydrate. A common ore of manganese. Perhaps H_4MnO_5.

Alabama, Arizona, Arkansas, California, Colorado, Georgia, Massachusetts, Montana, Nevada, New Mexico, North Carolina, South Carolina, Tennessee, Vermont, Virginia.

Pumice. Highly vesicular lava.

California, Idaho, Kansas, Nebraska, South Dakota, Wyoming.

Pyrargyrite, Dark ruby silver. Silver-antimony sulphide, $3Ag_2S.Sb_2S_3$. Contains 59.9 per cent silver when pure, but analyses show from 57 to 60.9 per cent.

Arizona, California, Colorado, Idaho, Maine, Montana, Nevada, New Mexico, Oregon, Washington.

Pyrite, Iron pyrites, Fool's gold. Isometrically crystallized iron disulphide, FeS_2. Contains 46.6 per cent iron.

Alabama, Arizona, California, Colorado, Connecticut, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Maine, Maryland, Massachusetts, Minnesota, Missouri, Montana, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming.

Pyrolusite, Black oxide of manganese. Manganese dioxide, MnO_2. Contains 63.2 per cent manganese.

Alabama, Arizona, Arkansas, California, Colorado, Georgia, Maryland, Massachusetts, Montana, Nevada, New Mexico, New York, North Carolina, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia.

Pyromorphite, Green lead ore. Chlorophosphate of lead, $3Pb_3P_2O_8.PbCl_2$.

Arizona, Colorado, Connecticut, Georgia, Idaho, Montana, Nevada, South Carolina.

Pyrope. Magnesium-aluminum garnet, $3MgO.Al_2O_3.3SiO_2$. Color deep red to nearly black. Used as a gem when transparent.

Arizona.

Pyrophyllite, Pencil stone. A hydrous aluminum silicate, $H_2O.Al_2O_3.4SiO_2$. Resembles talc in color, feel, luster, and structure. Used for slate pencils and for the "talc" or "talcum" of commerce.

California, North Carolina.

Pyrrhotite, Magnetic pyrites. A variable iron sulphide, Fe_nS_{n+1}. Many pyrrhotites contain nickel and are mined as nickel ores.

Alabama, Arizona, California, Colorado, Connecticut, Idaho, Maine, Maryland, Massachusetts, Montana, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, Oregon, Pennsylvania, South Carolina, South Dakota, Tennessee, Vermont, Virginia, Washington, Wyoming.

Quartz, Silica. Crystallized silicon dioxide, SiO_2.

Amethyst is a variety of the well-known amethystine color.

Aventurine is a quartz spangled with scales of mica, hematite, or other minerals.

False topaz or citrine is a yellow quartz.

Rock crystal is a watery clear variety.

Rose quartz is a pink variety.

Rutilated quartz contains needles of rutile.

Smoky quartz is a brownish variety sometimes called cairngorm.

Tiger-eye is crocidolite (an asbestos-like mineral) replaced by quartz and iron oxide, and having a chatoyant effect.

Alabama, Arizona, Arkansas, California, Colorado, Connecticut, District of Columbia, Delaware, Georgia, Iowa, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New York, North Carolina, Pennsylvania, Rhode Island, South Dakota, Texas, Virginia, West Virginia.

Quartzite. A sandstone in which the grains are so cemented by silica that they break across when the rock is fractured.

Arizona, Iowa, Michigan, Minnesota, Nevada, South Dakota, Virginia, Wisconsin.

Quicksilver. *See* Mercury and Cinnabar.

California, Colorado, Nevada, Oregon, Texas, Utah.

Radium. A metallic element, Ra, derived through a series of intermediate elements from uranium. It gives off helium (the α rays) and alters to emanation. Successive alterations give other elements, part of which radiate β and γ rays. Radium is never found in sufficient quantity to be visible, but occurs with and only with uranium minerals. From these it is separated to obtain the radium salts of commerce. *See* Uranium.

Realgar. Arsenic monosulphide, AsS. Contains 70.1 per cent elemental arsenic.

Utah, Washington.

Red iron ore. *See* Hematite.

Red oxide of zinc. *See* Zincite.

Reddle. Ocherous red clay.

Arkansas.

Rhodochrosite. Manganese carbonate, $MnCO_3$.

Colorado, Georgia.

Rhodolite. A variety of garnet characterized by its roselike color and brilliant luster. Composition corresponds to 2 molecules of pyrope and 1 of almandite.

North Carolina.

Rhodonite. Manganese silicate, $MnSiO_3$.

California, Maine, Massachusetts, Montana, New York, Rhode Island.

Rhyolite. A highly siliceous compact or porphyritic variously colored volcanic rock. An extrusive form of granite.

Wisconsin. Found in many other States, but little utilized.

Road material. *See* Road metal.

Road metal. Rock suitable for surfacing macadamized roads and for foundations for asphalt and concrete roadways.

Alabama, California, Connecticut, District of Columbia, Delaware, Georgia, Indiana, Iowa, Maryland, Massachusetts, Michigan, Mississippi, Missouri, Nebraska, New Jersey, New York, North Dakota, Rhode Island, Virginia, Washington.

Rock salt. *See* Halite.

Roscoelite. A vanadium-bearing muscovite mica in which Al_2O_3 is partly replaced by V_2O_3. The content of V_2O_3 may reach an equivalent of 28.85 per cent V_2O_5, though generally much less.

Colorado.

Rose quartz. Crystalline quartz with a rose-pink color. Used as a gem or as an ornamental stone. *See* Quartz.

Rosinjack. *See* Sphalerite.

Rowlandite. Yttrium silicate, $2Yt_2O_3.3SiO_2$.

Texas.

Rubellite. Dark-pink or red tourmaline. *See* Tourmaline.

California.

Ruby. Clear red corundum, Al_2O_3. A well-known gem.

Georgia, North Carolina.

Ruby silver. *See* Proustite and Pyrargyrite.

Rutile. Tetragonally crystallized titanium oxide, TiO_2. Octahedrite is another tetragonal form with different facial angles. When crystallized in orthorhombic form titanium oxide is known as brookite.

Arkansas, Colorado, Connecticut, North Carolina, South Carolina, Virginia.

Salt, Halite, Common salt. Sodium chloride, NaCl.

Alabama, Arizona, California, Idaho, Indiana, Kansas, Kentucky, Louisiana, Michigan, Nevada, New Mexico, New York, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Tennessee, Texas, Utah, Virginia, West Virginia, Wyoming.

Saltpeter. *See* Niter.

Samarskite. A columbate and tantalate of uranium, the cerium metals, the yttrium metals, and minor quantities of other metals.

North Carolina.

Sand, building. Any hard, granular rock material finer than gravel and coarser than dust. As used in this work the term indicates material comminuted by natural means. Quartz grains generally predominate in natural deposits, although such deposits commonly contain many other minerals.

All States.

Sand, glass. Sand of medium grain consisting of 98 to 100 per cent of silica (SiO_2), used in glass making. Iron oxides should form less than 1 per cent of the mass.

Alabama, Arkansas, California, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Mississippi, Missouri, Nevada, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Vermont, Virginia, West Virginia, Wisconsin, Wyoming.

Sand, molding. A sand used in making molds for casting metal.

Alabama, Arkansas, California, Colorado, Connecticut, Delaware, Georgia, Illinois, Indiana, Iowa, Kentucky, Maryland, Massachusetts, Michigan, Mississippi, Minnesota, Missouri, Nebraska, New Jersey, New York, Ohio, Pennsylvania, South Carolina, Tennessee, Texas, Vermont, Virginia, Washington, West Virginia, Wisconsin.

Sandstone, asphaltic. A loose-textured sandstone containing asphalt.

Sandstone, bituminous. *See* Sandstone, asphaltic.

Sandstone, bluestone. A tough bluish sandstone used for flagging.

Sandstone, brownstone. A sandstone of brown or reddish-brown color. Used for building.

Sandstone, building. A sandstone suitable for building.

Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Georgia, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Mississippi, Minnesota, Missouri, Montana, Nebraska, Nevada, New Jersey, New Mexico, New York, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, Wyoming.

Sandstone, flagstone. A sandstone which cleaves into flags suitable for sidewalks and areaways. Includes most bluestone.

Sandstone, freestone. A sandstone which cuts with equal ease in any direction. Used for building.

Sapphire. Clear blue corundum, Al_2O_3. A well-known blue gem. There are also white, pink, and yellow sapphires.

California, Connecticut, Georgia, Indiana, Montana, North Carolina.

Satelite. The gem trade name for a fibrous serpentine having a chatoyant effect.

California.

Scheelite. Calcium tungstate, $CaWO_4$. Contains 80.6 per cent tungsten trioxide, WO_3.

Arizona, California, Colorado, Connecticut, Idaho, Montana, Nevada, New Mexico, South Dakota, Utah, Washington.

Schist. A thinly laminated or foliated metamorphic rock which splits more or less easily along closely spaced, nearly parallel planes.

Massachusetts, Vermont, Virginia.

Scorodite. Hydrous ferric arsenate, $Fe_2O_3.As_2O_5.4H_2O$.

Utah, Washington.

Scythestone. A whetstone suitable for sharpening scythes.

Selenite. Gypsum in distinct crystals or broad folia, $CaSO_4.2H_2O$. *See* Gypsum.

Selenium. An element, Se. Not found native in visible quantity. Is obtained as a by-product in the electrolytic refining of copper. *See* Onofrite and Tiemmanite.

Sepiolite. *See* Meerschaum.

Serpentine. (*a*) Hydrous magnesium silicate, $3MgO.2SiO_2.2H_2O$. (*b*) A rock composed mostly of the mineral serpentine.

Arizona, California, Colorado, Connecticut, Delaware, Georgia, Maryland, Massachusetts, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Texas, Vermont, Washington.

Shale. A fine-grained rock formed by the consolidation of silt or clay, and fissile along bedding planes.

Alabama, Georgia, Iowa, Michigan, Nevada, Pennsylvania, Tennessee, Wyoming.

Siderite, Spathic iron ore. Iron carbonate, $FeCO_3$. Contains 48.2 per cent iron.

Colorado, Connecticut, Illinois, Indiana, Kansas, Kentucky, Maryland, Massachusetts, Mississippi, New York, North Carolina, Ohio, Pennsylvania, South Carolina, Tennessee, Vermont, Virginia, West Virginia.

Sienna. A brownish orange-yellow clay colored by iron and manganese oxides. Used as a pigment.

Alabama, California, Pennsylvania.

Silica. An oxide of silicon, SiO_2. Occurs in nature as a mineral of economic importance in quartz, chalcedony, chert, flint, opal, infusorial earth, and shale (which see), also as a constituent of all the silicate minerals. The most abundant constituent of the earth's crust. *See also* Agate, Quartz, Sand, glass, and in Illinois (p. 71) Silica, amorphous.

Silver. An element, Ag. Sometimes found native. *See* Acanthite, Amalgam, Argentite, Brongniardite, Bromyrite, Calaverite, Cerargyrite, Dyscrasite, Electrum, Embolite, Freibergite, Freieslebenite, Hessite, Iodyrite, Krennerite, Nagyagite, Petzite, Polybasite, Proustite, Pyrargyrite, Stephanite, Stetefeldtite, Stromeyerite, Sylvanite, Xanthoconite.

Arizona, Arkansas, California, Colorado, Georgia, Idaho, Iowa, Illinois, Kentucky, Maine, Maryland, Michigan, Minnesota, Missouri, Montana, Nevada, New Hampshire, New Mexico, North Carolina, Oregon, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Washington, Wyoming.

Silver glance. *See* Argentite.

Sipylite. A columbate of erbium chiefly, also of the cerium metals and other metals.

Virginia.

Slate. A dense, fine-textured metamorphic rock whose separate minerals are indistinguishable to the unaided eye, and which has an excellent parallel cleavage, so that it breaks into thin plates or pencil-like shapes.

Alabama, Arizona, Arkansas, California, Connecticut, Georgia, Maine, Maryland, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Pennsylvania, Tennessee, Utah, Vermont, Virginia, West Virginia.

Smaltite. Cobalt diarsenide, $CoAs_2$. Contains, when pure, 28.2 per cent cobalt. Through replacement of the cobalt by nickel it grades into chloanthite, the nickel arsenide, $NiAs_2$.

Colorado.

Smithsonite. Carbonate of zinc, $ZnCO_3$. Contains 52 per cent zinc.

Arizona, Arkansas, California, Illinois, Iowa, Kansas, Kentucky, Maryland, Missouri, Nevada, New Mexico, Oklahoma, Pennsylvania, Tennessee, Texas, Virginia, Wisconsin.

Soapstone. *See* Talc.

Alabama, Arkansas, California, Georgia, Maryland, Massachusetts, New Hampshire, New Jersey, North Carolina, South Carolina, Vermont, Virginia.

Soda. *See* Natron, Salt, Thenardite, Urao (Trona).

California, Nevada.

Soda feldspar. *See* Albite.

Spathic iron ore. *See* Siderite.

Specularite, Specular hematite, Specular iron, Gray hematite. An iron oxide, Fe_2O_3, occurring in tabular or disklike crystals of gray color and splendent metallic luster. Also called "micaceous hematite" if occurring in foliated or micaceous masses. Contains 70 per cent iron. *See* Hematite.

Arizona, Idaho, Michigan, Minnesota, Missouri, New Mexico, Wisconsin.

Sperrylite. Platinum arsenide, $PtAs_2$. The theoretically pure mineral would contain 56.5 per cent platinum, but antimony and rhodium are also present in small quantities.

Wyoming.

Spessartite. A variety of garnet. *See* Garnet.

Virginia.

Sphalerite, Blende, Blackjack, Jack, Rosinjack, Zinc blende. A sulphide of zinc, ZnS, crystallizing in isometric forms. Contains 67 per cent zinc. *See* Wurtzite.

Alabama, Arizona, Arkansas, California, Colorado, Connecticut, Georgia, Idaho, Illinois, Iowa, Kansas, Kentucky, Maine, Maryland, Massachusetts, Minnesota, Missouri, Montana, Nevada, New Hampshire, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, Washington, Wisconsin, Wyoming.

Spinel. An isometric mineral, typically magnesium aluminate, $MgO.Al_2O_3$. The magnesium may be in part replaced by ferrous iron, or manganese, and the aluminum by ferric iron and chromium. Spinel is red, yellow, green, black, and other colors, and is used as a gem.

California, Colorado, Massachusetts, Montana, New York, North Carolina.

Spodumene. Lithium-aluminum silicate, $Li_2O.Al_2O_3.4SiO_2$. Used as a source of lithia, of which it contains as a maximum 8.4 per cent. The clear green variety, known as hiddenite, and the clear pink or lilac, known as kunzite, are used as gems.

California, Connecticut, North Carolina, South Dakota.

Staurolite. Iron-aluminum silicate, $Fe(AlO)_4(Al,OH)(SiO_4)_2$. Sometimes used as a gem.

North Carolina, Virginia.

Stephanite, Brittle silver ore. Silver-antimony sulphide, $5AgS.Sb_2S_3$. Contains 68.5 per cent silver.

Colorado, Maine, Montana, Nevada.

Stetefeldite. A somewhat uncertain compound containing silver, copper, iron, antimony, sulphur, and water.

Nevada.

Stibiconite, Antimony ocher. Hydrous oxide of antimony, $Sb_2O_4.H_2O$. Contains 74.5 per cent antimony.

Nevada.

Stibnite, Antimony glance, Gray antimony, Sulphuret of antimony. Antimony sulphide, Sb_2S_3. Contains 71.4 per cent antimony.

Arizona, Arkansas, California, Colorado, Idaho, Maryland, Montana, Nevada, New Mexico, Oregon, Utah, Washington.

Stromeyerite. A somewhat variable sulphide of silver and copper, $(Ag,Cu)_2S$. Contains 50.2 to 52.7 per cent silver and 30.5 to 33.7 per cent copper.

Arizona, California, Colorado, Nevada.

Strontianite. Strontium carbonate, $SrCO_3$.

New York, Texas.

Sulphur. An element, S. Frequently found native.

Alabama, California, Colorado, Georgia, Idaho, Kentucky, Louisiana, Nevada, New Mexico, Tennessee, Texas, Utah, Wyoming.

Sulphuret of antimony. *See* Stibnite.

Sunstone. A variety of oligoclase feldspar containing numerous small inclusions which cause a delicate play of colors. Used as a gem.

Arkansas, North Carolina, New York, Virginia.

Syenite. A granular igneous rock composed typically of orthoclase or microcline, and hornblende. In mica syenites hornblende is replaced by biotite, and in augite syenites it is replaced by augite. If a small quantity of quartz is present it is called quartz syenite. In nepheline syenite the feldspar is partly replaced by nepheline.

Arkansas, Virginia.

Sylvanite. A gold-silver telluride, $(Au,Ag)Te_2$, containing gold and silver in the atomic ratio of 1 to 1. This requires 24.5 per cent of gold and 13.4 per cent silver.

Colorado, Oregon, Washington, Wyoming.

Tabbyite. *See* Wurtzilite.

Talc. A hydrous magnesium silicate, $H_2O.3MgO.4SiO_2$. Has a greasy or soapy feel and is soft and easily cut. Occurs in beds more or less impure and is then known as steatite or soapstone. Also called potstone because it has been used for pots owing to the ease with which it is worked and to its resistance to ordinary heats. French chalk is a variety used for crayons. *See* Soapstone.

Arkansas, California, Georgia, Maine, Maryland, Massachusetts, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, Texas, Vermont, Virginia, Washington.

Tantalite. The member of the tantalite-columbite group of minerals which is composed of nearly or quite pure tantalate of iron and manganese. Nearly all tantalite contains some columbium. The members of the group containing more columbium are known as columbite. Tantalite is very rare. Pure tantalite, $(Fe,Mn)Ta_2O_6$, would contain about 86 per cent Ta_2O_5, or 70.4 per cent tantalum, but the percentage in actual minerals is generally much lower.

South Dakota, Virginia.

Tengerite. Of doubtful composition, said to be yttrium carbonate.

Texas.

Tennantite, Gray copper ore. Copper-arsenic sulphide, $3Cu_2S.As_2S_3$. Contains 57.5 per cent copper. Composition varies as in tetrahedrite, into which it grades.

Colorado, Montana, Wyoming.

Tenorite. Black oxide of copper in minute black scales, CuO. Contains 79.8 per cent copper.

Arizona, New Mexico, Oregon, Utah, Wyoming.

Tephroite. Manganese orthosilicate, $2MnO.SiO_2$. Contains 70 per cent MnO, and commonly also small quantities of magnesium, iron, and zinc.

New Jersey.

Terlinguaite. Oxychloride of mercury; Hg_2ClO. Contains 88.65 per cent mercury.

Texas.

Tetradymite. Bismuth telluride, $Bi_2(Te, S)_3$. Contains theoretically 51.9 per cent bismuth, but the actual content ranges from 50.4 to 52.8 per cent. Sulphur generally replaces part of the tellurium, and the mineral sometimes contains a trace of selenium. The sulphurous variety contains from 57.7 to 62.2 per cent bismuth, and may be represented by the formula $2Bi_2Te_3.Bi_2S_3$. Gold, copper, and iron are present in some tetradymites.

Arizona, California, Colorado, Maryland, Montana, New Mexico, North Carolina, South Dakota, Virginia.

Tetrahedrite, Gray copper ore. Copper-antimony sulphide, essentially $3Cu_2S.Sb_2S_3$. Contains 52.1 per cent copper. In many tetrahedrites the copper is partly replaced by iron, lead, zinc, mercury, and silver, and the antimony by arsenic. Through the last replacement tetrahedrite grades into tennantite.

Arizona, California, Colorado, Idaho, Massachusetts, Montana, Nevada, New Mexico, North Carolina, Oregon, Tennessee, Utah, Washington.

Thenardite. Sodium sulphate, $Na_2O.SO_3$.

Arizona.

Thomsonite. Hydrous sodium-calcium-aluminum silicate, $(Na_2,Ca)O.Al_2O_3.2SiO_2.2\frac{1}{2}H_2O$. One of the zeolites, sometimes used as a gem.

Michigan.

Thorianite. A mineral of complex and uncertain composition but consisting chiefly of thorium and uranium oxides with minor quantities of many other bases. Contains about 12.1 per cent U_3O_8 and 71 per cent ThO_2.

Montana.

Thorium. An element, Th. One of the rare-earth metals. Not found native. *See* Auerlite, Monazite, Thorianite, Thorogummite, Yttrialite.

Thorogummite. A hydrous silicate of uranium and thorium, $UO_3.3ThO_2.3SiO_2.6H_2O$. Contains 22 per cent UO_3 and 41 per cent ThO_2.

Texas.

Tiemmanite. Mercuric selenide, $HgSe$. Contains 71.7 per cent mercury and 28.3 per cent selenium.

Utah.

Tin. A white malleable metallic element, Sn. Found in nature probably only in combination, principally as tin oxide, cassiterite. *See* Cassiterite.

Tincal. *See* Bornite.

Topaz. An aluminum fluosilicate, simplest formula $Al_2SiO_4F_2$, but with part of the fluorine commonly replaced by HO. Used as a gem, especially when yellow.

California, Colorado, Connecticut, Maine, New Hampshire, Texas, Utah.

Torbernite. A hydrous phosphate of uranium and copper, $CuO.2UO_3.P_2O_5.8H_2O$.

South Dakota.

Tourmaline. A complex aluminum silicate of hexagonal crystallization containing boron and in some varieties lithium and other elements. Of various colors; the clear pink, blue, and green varieties are used as gems.

California, Colorado, Connecticut, Georgia, Maine, Maryland, Massachusetts, North Carolina, Virginia.

Trap, Trap rock. A general name for dark fine-grained igneous rocks, particularly lavas or dikes. *See also* Basalt and Diabase.

California, Connecticut, Delaware, Massachusetts, Michigan, Minnesota, New Jersey, New York, Pennsylvania, Vermont, Virginia, Wisconsin.

Travertine. Carbonate of lime, $CaCO_3$, deposited from solution in ground and surface waters. The cellular deposits are known as tufa, calcareous sinter, spring deposit, or cave deposit. When solid, banded, and susceptible of a good polish, it is known as Mexican onyx, or onyx marble. True onyx, however, is banded silica or agate. Travertine forms the stalactites and stalagmites of caves, and the filling of some veins and spring conduits.

Utah.

Tremolite. White fibrous amphibole, $CaMg_3Si_4O_{12}$.

Connecticut, Georgia.

Tripoli. A porous siliceous rock resulting from the decomposition of siliceous limestone. Used for polishing powder and filters.

Alabama, Arkansas, Georgia, Illinois, Indiana, Iowa, Kentucky, Maine, Maryland, Minnesota, Missouri, Oklahoma.

Tripolite. *See* Infusorial earth.

Trona. An impure form of urao. *See* Urao.

California, Colorado, Nevada, Wyoming.

Tufa. *See* Travertine.

California, Utah, Washington.

Tuff. Fragmental rock ejected from a volcano. It ranges from very fine, powdery material to coarse, heavy fragments. *See* Volcanic ash.

California.

Tungsten. A metallic element, W. Not found native. *See also* Ferberite, Hübnerite, Scheelite, Wolframite.

Arizona, California, Colorado, Idaho, Nevada, New Mexico, South Dakota, Washington.

Turquoise. Hydrous phosphate of aluminum and copper, $CuO.3Al_2O_3.2P_2O_5.9H_2O$. Used for the well-known gem of the same name.

Arizona, California, Colorado, Nebraska, Nevada, New Mexico, Texas.

Uintaite. *See* Gilsonite.

Utah.

Ulexite, Cotton ball. Hydrous borate of sodium and calcium, probably $Na_2O.2CaO.5B_2O_3.16H_2O$. Contains theoretically 43 per cent B_2O_3. Analyses of the natural mineral show from 42 to 45.3 per cent B_2O_3.

California, Nevada.

Umber. A chestnut-brown to liver-colored hydrated ferric oxide containing manganese oxide and clay. As found in nature it is called raw umber, and when heated so as to produce a reddish brown it is called burnt umber.

Pennsylvania, Vermont, Virginia.

Uraninite. A complex uranium mineral containing also rare earths, radium, lead, helium, nitrogen, and other elements. Uraninite in the stricter sense is applied to crystallized forms found in pegmatites. It contains Th, Ce, La, and Yt. The mineral found in Connecticut and North Carolina is of this variety. Pitchblende is the massive form, probably amorphous, and contains no thoria, but a specimen from Gilpin County, Colo., contained 7.6 per cent zirconia. Pitchblende is found in metalliferous veins with sulphides. Both varieties contain radium. Contains from 65 to 90.7 per cent of the combined oxides UO_3 and UO_2. *See also* Nivenite.

Colorado, Connecticut, North Carolina.

Uranium. A heavy metallic element, U. Not found native. All uranium minerals contain radium. *See* Autunite, Carnotite, Fergusonite, Mackintoshite, Nivenite, Polycrase, Samarskite, Thorianite, Thorogummite, Torbernite, Uraninite (including Pitchblende), Uranocircite, Uranophane, Uranospinite, Yttrialite.

Uranocircite. A hydrous phosphate of uranium and barium, $BaO.2UO_3.P_2O_5.8H_2O$.

South Dakota.

Uranophane. A hydrous silicate of uranium and calcium, $CaO.2UO_3.2SiO_2+6H_2O$.

North Carolina.

Uranospinite. Probably an arsenate of uranium and calcium corresponding to autunite, $CaO.2UO_3.As_2O_5.8H_2O$. Contains about 47.6 per cent uranium, equivalent to 56.1 per cent calculated as U_3O_8.

Utah.

Urao. Hydrous sodium carbonate, $3Na_2O.4CO_2.5H_2O$. Trona is an impure form of urao.

Utahlite. *See* Variscite.

Valley brown ore. A local name for limonite or brown iron ore. Applied in Virginia to the comparatively pure high-grade ore found in the Cambro-Ordovician limestone which forms the Valley of Virginia. *See* Mountain brown ore.

Virginia.

Vanadinite. Lead chlorvanadate, $9PbO.3V_2O_5.PbCl_2$. Contains when pure 19.4 per cent V_2O_5, but arsenic and phosphorus both replace vanadium, so that the mineral grades into mimetite, $3Pb_3As_2O_8.PbCl_2$, and into pyromorphite, $3Pb_3P_2O_8.PbCl_2$. Endlichite is a variety of vanadinite containing considerable arsenic.

Arizona, Montana, Nevada, New Mexico.

Vanadium. An element, V. It does not occur native but is found in the United States in the minerals carnotite, roscoelite, vanadinite, descloizite, volborthite, calciovolborthite, and aegirite.

Arizona, Colorado, Montana, New Mexico, Utah.

Variscite, Utahlite. Green hydrous phosphate of aluminum, $Al_2O_3.P_2O_5.4H_2O$. Used as a gem.

Arkansas, Nevada, Utah.

Verde antique. A dark-green rock composed essentially of serpentine (hydrous magnesium silicate). Usually crisscrossed with white veinlets of magnesium and calcium. Used as an ornamental stone. In commerce often classed as a marble.

California, Georgia, Maryland, Massachusetts, New York, Virginia.

Verde salt. *See* Thenardite.

Vesuvianite. A complex calcium-aluminum silicate of uncertain formula. A massive light-green variety is known as californite.

Arkansas, California.

Volborthite. A hydrous vanadate of copper, barium, and calcium.

Arizona, Colorado.

Volcanic ash, Volcanic tuff. A material made up of either loose or solidified small fragments and dust of lava, commonly glassy in character, blown from a volcano and deposited either on land or under water. If numerous large fragments are embedded in the ash, the deposit is called volcanic agglomerate or volcanic breccia.

Colorado, Montana, Nevada, Oklahoma, South Dakota.

Volcanic glass. *See* Obsidian.

Volcanic tuff. *See* Volcanic ash.

Wad, Bog manganese. An impure mixture of manganese and other oxides. It contains 10 to 20 per cent of water, and is generally soft, soiling the hand. A variety known as asbolite carries as much as 32 per cent cobalt.

Arizona, Arkansas, California, Georgia, Maine, Massachusetts, Missouri, Montana, Nevada, New Mexico, New York, Pennsylvania, Rhode Island, South Carolina, Tennessee, Virginia, Wisconsin.

Water sapphire. *See* Cordierite.

Wavellite. Hydrous aluminum phosphate, $3Al_2O_3.2P_2O_5.12H_2O$. Fluorine is present in some specimens up to 2 per cent.

Alabama, Pennsylvania.

Whetstone. A stone suitable for sharpening tools.

Arkansas, Connecticut, Indiana, Massachusetts, Michigan, New Hampshire, Rhode Island, Vermont.

White iron pyrite. *See* Marcasite.

Williamsite. An apple-green impure variety of serpentine. *See* Jade.

Willemite. Zinc silicate, $2ZnO.SiO_2$. Contains 58.6 per cent zinc. The zinc is commonly replaced in part by manganese.

Arizona, New Jersey, New Mexico.

Wolframite. A series of minerals composed of tungstate of iron and manganese $(Fe,Mn)WO_4$, containing, when the iron and manganese are in a ratio of 1 to 1, 76.4 per cent WO_3. As the iron increases and the manganese decreases wolframite grades into ferberite, the pure iron tungstate, $FeWO_4$, with 76.3 per cent WO_3. At the other end of the series is hübnerite, the pure manganese tungstate, containing 76.6 per cent WO_3.

Arizona, California, Connecticut, Nevada, New Hampshire, New Mexico, South Dakota, Texas, Virginia, Washington, Wyoming.

Wood, silicified, Petrified wood, Opalized wood, Agatized wood. A material composed of opal or chalcedony (agate) and formed by the replacement of wood by silica. The replacement of the woody matter by the silica takes place in such a way that the original form and structure of the wood is preserved.

Arizona, California, Colorado, South Dakota, Utah, Wyoming.

Wulfenite. Lead molybdate, $PbMoO_4$. Contains 39.3 per cent MoO_3. Calcium, chromium, copper, and vanadium are sometimes constituents.

Arizona, Massachusetts, Nevada, New Mexico, Pennsylvania, Utah.

Wurtzilite, Elaterite, Tabbyite, Æonite, Ægerite. An asphaltic mineral which is jet-black by reflected light and deep red in thin plates. It softens in hot water, toughens, and becomes more elastic. In a candle flame it softens and burns with a bright flame. It is practically insoluble in gasoline of 76° B., partly soluble in ether, carbon disulphide, and turpentine, and less so in carbon tetrachloride.

Utah.

Wurtzite. A zinc sulphide of the same composition as sphalerite, ZnS, but hexagonal in its crystallization.

Montana, Utah.

Xanthoconite. Silver-arsenic sulphide, $3Ag_2S.As_2S_5$. Contains 61.4 per cent silver.

New Mexico.

Xenotime. Essentially yttrium phosphate, $YtPO_4$. Contains phosphorus pentoxide 38.6, yttria 61.4.

North Carolina.

Yellow copper. *See* Chalcopyrite.

Yttrialite. Silicate of thorium and the yttrium metals chiefly, but it contains also uranium and other elements in small quantity.

Texas.

Zaratite. A massive, vitreous emerald-green hydrous nickel carbonate, $H_{12}Ni_3CO_{11}$. Occurs usually as an incrustation.

Maryland.

Zeolites. A group of minerals occurring in cracks and cavities of igneous rocks, especially the more basic lavas. Zeolites are hydrous silicates of aluminum with either sodium or calcium or both, and rarely barium or strontium. Before the blowpipe most of the zeolites fuse readily and with strong intumescence, whence their name, derived from the Greek, of "boiling stone." They have little economic importance.

Zinc. An element, Zn. Not found native. *See* Calamine, Franklinite, Hydrozincite, Nicholsonite, Smithsonite, Sphalerite, Willemite, Wurtzite, Zincite.

Zinc blende. *See* Sphalerite.

Zinc bloom. *See* Hydrozincite.

Zincite, Red oxide of zinc. Zinc oxide, ZnO. Contains 80.3 per cent zinc.

New Jersey.

Zircon. Zirconium silicate, $ZrSiO_4$. When clear and orange-colored it is used for the gem known as hyacinth.

New Jersey, New York, North Carolina, Oregon, Texas, Virginia.

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 586

SLATE IN THE UNITED STATES

BY

T. NELSON DALE AND OTHERS

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SLATE IN THE UNITED STATES.

By T. Nelson Dale and others.

INTRODUCTION.

By T. Nelson Dale.

Bulletin 275 of the United States Geological Survey, "Slate deposits and slate industry of the United States," issued in 1906, included, besides the results of the writer's field and microscopic work on the slates of New England, New York, Pennsylvania, Maryland, and Virginia, a series of elaborate analyses of slate and a note by W. F. Hillebrand, the results of E. C. Eckel's visits to the slate districts of California, Utah, and Arkansas, and a series of physical tests of slates made for the Survey by Mansfield Merriman.

Since the publication of that bulletin, the edition of which was exhausted several years ago, slates of more or less economic value have been found in Merced County, Cal., in Colorado, in Bartow County, Ga., in Nevada, in Lancaster and Dauphin counties, Pa., and in Monroe County, Tenn., and all of them have been examined microscopically by the writer. He has also recently visited some of the prospects and quarries in Georgia and Tennessee, and the quarries of Penlan and Esmont, Va., of Sussex County, N. J., and of Aquashicola and Windgap, Pa., and has revisited some of the Maine and Vermont slate districts. Since the publication of Bulletin 275, A. H. Purdue's studies of the slate region of Arkansas have also appeared and two papers by T. L. Watson on the slates of Virginia.

The present bulletin is not only a corrected and revised edition of Bulletin 275, but contains also the results of all these recent discoveries and studies. Its plan is to set forth in Part I, in succinct form, the present state of scientific knowledge as to the origin, structure, texture, and chemical and mineral composition of slate; in Part II to describe in more or less detail the slates and quarries of each district; and in Part III to consider the economic geology of slate, including the scientific prospecting for slate, the methods of testing it, slate machinery, the uses of slate and slate waste, together with a tabular summary of all the slates described.

Geologists will find in Part II geologic notes on many of the slate districts, data as to the weathering of the slates of Pennsylvania, Maryland, and Georgia, and petrographic descriptions of all the slates. Those of Maine, Maryland, New York, Pennsylvania, Vermont, and Virginia are treated most fully. The accounts of the various lenses in slate, given on pages 70, 86, 91, 93, 112, 122, and 157, will probably interest petrographers.

A bibliography of slate, both economic and scientific, and a glossary of geologic and slate-quarry terms are appended.

Mr. C. A. Bonine, now of this Survey, has kindly made contributions from his Lehigh University thesis, "The slate deposits of Northampton County, Pa.," written prior to his connection with this Survey. These include the map (Pl. XV) showing the locations of the slate quarries of that county, and also several paragraphs on its stratigraphy, which are credited to him in their place.

In the geologic mapping of the slate belt of western Vermont and eastern New York the writer was assisted in 1895–96 by Messrs. L. M. Prindle and F. H. Moffit. The quarry sites on the map of Slatington, Pa. (Pl. XVI), were located by Mr. Moffit.

As in Bulletin 275, Miss A. T. Coons contributes a chapter on the statistics of slate production.

The portions of this bulletin not specifically credited to others have been prepared by the writer.

PART I.—ORIGIN, COMPOSITION, TEXTURE, AND STRUCTURE OF SLATE.

DEFINITION AND CLASSIFICATION OF SLATE.

The term *slate,* in ordinary usage, denotes a rock which has more or less perfect cleavage, being thus adapted to various commercial uses, and in which the constituent particles, with very few exceptions, can not be distinguished except in thin section under a microscope. In contradistinction a *schist* is a rock that may be of identical chemical and mineral composition but is either made up of coarser particles or possesses a wavy structure, or else is marked by both of these features. Both slates and schists may have originated in deposits of identical character, but they have undergone different processes.

Slates as above defined vary greatly in color—from black through various shades of gray to greens, reds, and purples of different hues. They vary also in luster—from having none to being almost as bright as mica itself. They vary greatly not only in grade of fissility but in surface texture, as seen by the unaided eye or determined by touch, and still more in microscopic texture, as seen in thin section. They differ also in their mineral and chemical composition and in their physical properties.

On account of their peculiar properties slates are adapted to a great variety of uses—roofing, flooring, electric switchboards, blackboards, hand slates, billiard and laboratory table tops, vats, tubs, mantels, grave linings, wainscoting, hearths, chimney and well caps, memorial tablets, bread boards, refrigerator shelves, etc. This stone has thus become linked with some of the principal necessities of life and death.

The appearance of large masses of fresh slate of good quality in cross fracture is shown in Plates XIII, XIV, and XIX.

Slates divide themselves naturally into (1) those derived from aqueous sediments and (2) those of igneous origin. The latter, however, are very exceptional. For commercial purposes the basis of classification of the aqueous sedimentary slates must be, first, textural, for the cost of their production and the degree of their strength depend primarily upon their texture; second, it must be mineralogic, for their durability depends upon their content of certain mineral constituents.

Slates in which the particles have been merely compressed by weight or pressure and cemented by carbonates of lime and magnesia, by kaolin, or by different combinations of iron, and whose fissility, strength, and elasticity are therefore low, must be distinguished from those in which, under metamorphic processes, the kaolin and feldspar have passed into mica, forming a more or less dense and regular crystalline fabric of overlapping scales and fibers inclosing any remaining sedimentary particles. Such slates necessarily possess a high grade of fissility and considerable strength and elasticity. The first group includes clay slates; the second mica slates or phyllite slates. Those in which the micaceous matrix is but partly formed and which represent a transition from clay slate to mica slate are more conveniently put into the clay slate group. Thus the dark-purple ("red") roofing slate of Penrhyn, in Wales, is a clay slate, and so also is the black slate of Martinsburg, W. Va.; but the French Ardennes slate, the Welsh Festiniog, and the Peach Bottom slate of Pennsylvania and Maryland are all mica slate.

But mica slate includes slates of very different composition and structure, and therefore of very different properties and value. The first distinction to be made is based upon the amount of ferrous carbonate—whether or not it is sufficient to produce discoloration on continued exposure to the weather—for this is an important factor in the value of slates used for roofing. This distinction gives a group of fading and one of unfading slates, each of which can be further subdivided as to color. But each of the color groups of fading and unfading mica slate embraces slates having a wide range of texture. Some, like the Arkansas black and light-greenish slates, have a matrix of extremely fine sericite fibers, while the black slates of Arvonia, Va., and the Peach Bottom slate have a texture approaching that of a schist. In some slates the sericite fibers are remarkably even and parallel; in others they make up minute elongated lenses, so that the slate in cross section is seen to consist of tiers of lenses. Such differences in texture can not but result in differences in physical properties. The grades of texture are sufficiently designated by the words very fine, fine, medium, and coarse. There are also distinctions in the grade of fissility which do not always correspond to the grade of texture. These are conveniently numbered from 1 to 4, beginning with those of the best fissility. Finally there are differences in luster and amount of magnetite—differences which are purely specific. The general distinctions are formulated in the following table:

Classification of slate.

I. Aqueous sedimentary:
    A. Clay slates: Matrix without any or with but very faint aggregate polarization.
    B. Mica slates: Matrix with marked aggregate polarization.
        1. Fading: With sufficient $FeCO_3$ to discolor considerably on prolonged exposure.
            (*a*) Carbonaceous or graphitic.
            (*b*) Chloritic (greenish).
            (*c*) Hematitic and chloritic (purplish).

I. Aqueous sedimentary—Continued.
  B. Mica slates: Matrix with marked aggregate polarization—Continued.
    2. **Unfading**: Without sufficient $FeCO_3$ to produce any but very slight discoloration on prolonged exposure.
      (*a*) Graphitic.
      (*b*) Hematitic (reddish).
      (*c*) Chloritic (greenish).
      (*d*) Hematitic and chloritic (purplish).
      (*e*) Hematitic, specular, and graphitic (bluish blackish).
II. Igneous.
  A. Ash slates.
  B. Dike slates.

The scientific basis for these subdivisions will be seen by consulting the table facing page 188 and the microscopic and chemical analyses of the slates there named. The application of this scheme to 20 kinds of American slates will be found on page 189.

ORIGIN OF SLATE.

With the exception of the rare slates of igneous origin, referred to in the previous section, slates originate in marine deposits of clay and sand. The common occurrence of angular grains of feldspar and of quartz in slate implies the nearness of shores or land masses of granitic rocks to such deposits. The alternation of beds of slate with beds of quartzite or grit ("ribbons," "hards," altered sandstone) corresponds to the alternation of extremely fine clayey sediments, derived from the waste of such granitic land masses with sandy sediments consisting of coarser material from the same source. The repeated alternation of such fine and coarse sediments is attributed to the alternation of calm water, favorable to the deposition of fine material, with strong currents that brought coarse sediments more rapidly from the shore. These materials consisted largely of quartz, feldspar, and mica but included also zircon and other silicates, various compounds of iron, lime, and magnesia, and kaolin arising from the decomposition of the feldspar. In such a slate region as that of western Vermont and eastern New York, where the slate is interbedded with fossiliferous limestone, it is evident that periods of such changing conditions in the water also alternated with periods when marine life abounded and the sediments were entirely calcareous. Black slates owe their blackness to carbonaceous matter, probably derived from the decomposition of marine organisms on the sea floor. Red slates owe their color to the access of ferruginous matter from the land, and purplish slates to an admixture of such matter and a green magnesian mineral (chlorite) of secondary origin. In both the reddish and the purplish slates the iron is supposed to have been originally precipitated in the form of the rust-colored limonite ($2Fe_2O_3.3H_2O$) from iron-bearing solutions and to have been afterward altered by loss of water (H_2O) to the reddish hematite (Fe_2O_3).[1]

An accumulation of several hundred feet of such clayey and sandy sediments when buried under several thousand feet more of other sediments of like origin on a gradually subsiding sea bottom must have been subjected to sufficient vertical pressure, in connection with a small amount of moisture, to be cemented together and hardened—the clay into shale and the sand into sandstone. During this process the particles in these sediments retained the general horizontal and parallel arrangement which they had received from their distribution by sea water but became firmly compacted and thus acquired a bedding foliation.

The next stage in the formation of slate is attributed ultimately to the radiation of heat from the earth's interior into space, resulting in a contraction of the interior and consequently in a corrugation of the outer portion. This corrugation, for reasons not yet perfectly evident, took place, so far as observation extends, chiefly within certain belts in which the mountain systems were formed from the lateral compression of a great mass of parallel strata. The first effect of this compression was to bend at least the lower portion of the strata into wavelike folds, and thus to shorten its horizontal area in one direction and increase its vertical thickness. The character of this folding is well shown in the slate regions of Pennsylvania and western Vermont. (See Pls. III; XIII; XIV; XVII; XVIII; XIX, *A;* XXII; XXV.) But another effect of this compression was to metamorphose the shale into slate. This metamorphism probably did not take place until the folding was well initiated. The transformation included two processes, and it is uncertain which preceded. Each individual sedimentary particle was rotated from its original horizontal position in the bedding foliation into one forming a considerable angle to the direction of pressure. There was also, under the combined presence of moisture and the effect of pressure and heat, both the heat which must have been generated by the pressure and that which pervaded the strata at the depth at which they were buried, such a chemical recombination of the silica, alumina, potash, iron, and water of the feldspar, kaolin, and iron of the shale as to generate new potash mica in amount sufficient to constitute, in the mica slates, over 33 per cent of the resulting slate. This muscovite was formed in scales of infinitesimal thinness and other dimensions and generally of longish, tapering, or ribbonlike outline. Most of these scales arranged themselves with their flat sides parallel to or overlapping one another but facing the direction from which the pressure came and also with an angle of inclination governed by that pressure. A small but variable proportion, however, of these scales took such a position that their flat sides became parallel to the direction of the pressure. As mica crystallizes in columnar crystals, and as the plates or scales due to its molecular structure are transverse to the crystal column, and as a slab of slate consists largely of parallel scales of mica it may be said to correspond when held horizontally to such a crystal held vertically. When a mica slate is cut in thin section across the cleavage its optical behavior under polarized light is like that of a mica crystal cut across its crystal cleavage. Yet as not only a considerable number of the mica scales in slate lie across the cleavage, but as some scales of chlorite and crystals of other minerals do also, the texture of a mica slate combines some of the features of a crystal with some of those of a tissue. Extremely thin sections of slate transverse to the cleavage may show this interlacing of the two sets of scales on their attenuated edges. It is to this microscopic texture that the slate largely owes its peculiar properties.

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[1] See on these changes Van Hise, C. R., A treatise on metamorphism: U. S. Geol. Survey Mon. 47, pp. 225, 232, 1904.

This crystalline fabric may inclose in its meshes any sedimentary particles of quartz, zircon, feldspar, kaolin, or other minerals which were not or could not be made over into mica or secondary quartz but whose alignment became more or less parallel to that of the major part of the new mica. During this metamorphism other chemical combinations were formed by the constituents of the shale, which crystallized in isolated scales or crystals of chlorite, biotite (magnesia mica), various carbonates, pyrite, magnetite, graphite, tourmaline, andalusite, etc. These arranged themselves variously—some in the cleavage direction, some in the grain direction. Lenses consisting of some one mineral surrounded by one or two others were also formed and concentrically or radiately arranged. The limonite became hematite. During these changes in the fine sediments the intercalated beds of sandstone passed into quartzite and metamorphic grit by the formation of siliceous and micaceous cement between their particles.

The essential part of the process of the transformation of a granitic rock into clay and of that into mica may be made generally intelligible by recalling two well-known experiments of Daubrée, the French geologist. In the first, angular fragments of granite and quartz were rapidly rotated in a horizontal iron cylinder filled with water and moving on an axis. The trituration resulted in producing a very fine clay. The second experiment consisted in inclosing clay and water in a closed wrought-iron tube, which was then placed in a gas furnace and exposed for several weeks to a very high temperature. The result was the production of scales of mica. In the first experiment the factors of stream and wave erosion were duplicated, and in the second the elements of moisture, pressure, and heat involved in the crystallization of new minerals from clay were reproduced.

Two other experiments illustrating the arrangement of the mica thus formed, as well as the sedimentary mica and other minerals, may well be cited here. The familiar one of Tyndall consisted in subjecting wax to pressure between glass plates and, after cooling it in ice and salt, breaking it edgewise with a hammer. The fractures showed that it had acquired slaty cleavage. The other experiment was made by Jannetaz and consisted in subjecting a mass of clay in a wrought-iron box, open at one side, to hydraulic pressure, which resulted in the formation not only of slaty cleavage but also of the grain texture.

The general microscopic texture of slate is such as to warrant the assumption that the compression which produced it operated not only with great uniformity but also very gradually.

The microscopic features of slate are more fully considered in the following section on the petrographic characters of slate. The above notes will suffice, however, to convey, with as few technical terms as possible, a general idea of the principal steps in the formation of a mica slate of aqueous sedimentary origin. The history of clay slate is similar, but the metamorphism to which it has been subjected has been insufficient to produce the micaceous texture.

After the slate was formed the mass was subjected to various stresses (tensions, shears, contractions), which resulted in several systems of joints, in faults, slip cleavage ("false cleavage"), shear zones ("hogbacks"), and irregular openings in which veins of quartz and calcite were formed by infiltration. Some masses were also traversed by fissures penetrating to the molten zone and thus permitting the exudation of lava-like material which formed dikes.

The folds into which the slate beds were bent are rarely complete, for the reason that their upper portions have generally been removed through various erosive processes—the decomposition due to atmospheric agencies, the action of streams, and, in places, the erosion of the continental glacier. Plates III, XIII, XIV, XVII, XVIII, and XXV all illustrate this feature. In the Appalachian region generally the thickness of this eroded material was very considerable.

From the foregoing statements it may be seen that a piece of slate is in itself a record of a long series of complex geographic, geologic, chemical, mineralogic, and physical processes of great scientific interest.

MINERALS OF SLATE AND THEIR ARRANGEMENT.

HISTORY OF RESEARCH.

However uncertain the structural, textural, mineral, and chemical features of roofing slates may once have seemed, these are all now well understood. Sedgwick, Sorby, Phillips, Tyndall, Daubrée, Gosselet, Jannetaz, and Becker have studied the structure of slates in the field or the laboratory or in both, and Sorby, Zirkel, Renard, and others have investigated their mineral composition. Summaries on the cleavage of slate were published by Loretz in 1880 and Harker in 1886, and on its petrography by Kalkowsky in 1886, Zirkel in 1894, and Rosenbusch in 1898. Chemical analyses are given in Roth's "Chemical geology" (1890), and in Zirkel's "Petrography" (1894). Hillebrand, Reade, and Holland made a number of complete analyses between 1899 and 1901. Van Hise, in his "Treatise on metamorphism"[1] (1904), discusses the theory of metamorphism in schists and slates, and Leith, in his paper on rock cleavage[2] (1905), treats of the theory of bedding and cleavage, basing his conclusions more largely on the microscopic study of schists than of roofing slates. The bibliography on pages 205–210 shows how much has been written on the different aspects of the subject. It is not proposed to give here a summary of all this literature, but an attempt will be made to set forth, in a series of statements, quotations, and questions, the state of scientific opinion on the more important and interesting features of slate.

Slaty cleavage may be defined simply as a rearrangement of the particles of a deposit by lateral pressure, together with the arrangement of any new crystalline particles formed during and in consequence of that pressure. This arrangement of old and new particles is related to the directions of pressure and resistance. The older authorities on slaty cleavage usually define the direction of pressure as being at 90° to the cleavage. This definition of the direction has, however, been under discussion in recent years. The latest phase of opinion appears in the writings of Van Hise, Becker, and Leith. Van Hise [1] expresses his views in these words:

> During the process of recrystallization at any given moment there is maximum shortening in the direction of greatest stress, maximum elongation in the direction of least stress, and shortening or elongation in the direction of mean stress. Consequently the shape of the modified particle may be that which would be produced if a plastic grain were rolled out, the sides being confined in one direction, but with liberty to elongate in another direction in the same plane; or it may be that which would be produced if a roundish cake of dough were flattened between two boards, and consequently elongated in all directions at right angles to the direction of greatest pressure. * * * The particles are arranged with their greater, mean, and minor diameters, corresponding to least, mean, and greatest pressures. In proportion as the movement involves shearing motion or scission the mineral particles are rotated from a position in which the direction of greatest elongation is at right angles to the direction of greatest pressure, although at any given time the mineral particles tend to develop with their longer axes at right angles to the maximum pressure.

Becker's experimental studies were directed to determining the mathematical character of the deformation undergone by a plastic but crystalline mass under pressure. For this purpose he pierced a block of ceresin with needle holes at regular intervals in both a vertical and a horizontal direction, drawing a thread smeared with coloring matter after the needle, and subjected the block to powerful vertical pressure. The curves then assumed by the colored lines enabled him to determine the position of the axes of the strain ellipsoid with relation to the direction of pressure. The result of this and of other experiments described in the same paper is that—

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[1] U. S. Geol. Survey Mon. 47, pp. 752, 753, 1904.

[2] U. S. Geol. Survey Bull. 239, 1905.

> cleavage does not coincide even approximately with the direction of the major axes of the strain ellipsoid. Neither does the cleavage correspond to the position of the major axes of the strain ellipsoids at any previous stage of the strain.[1]

In other words, slaty cleavage is not perpendicular to the smallest axis of the strain ellipsoid but makes with "that axis an acute angle equal or greater than 45° and increasing as the strain grows greater." Both the experiments and the reasoning seem simple and clear.

Leith, following Van Hise, states that—

> Cleavage is always tending to develop normal to the greatest principal stress, but its final position may or may not be inclined to the greater stress, depending upon the nature of the strain.[2]

This question of the relation of the dip of slaty cleavage to the direction of pressure is not purely speculative but bears directly upon problems in field geology. Thus where cleavage is nearly horizontal it is probable that a secondary crustal movement must have diminished the original inclination of the cleavage and consequently the whole attitude of the folds. Were the limiting angle at which slaty cleavage forms established, then, in the case stated, a maximum figure for the angular displacement of the cleavage could be obtained.

There is some vagueness in scientific literature, as well as in popular conception, as to what constitutes a slate. Sorby drew this distinction:

> When a section [of a fine-grained slate] cut at right angles to the cleavage is rotated in polarized light it becomes, over nearly the whole surface, very bright, and much darker at different azimuths, like a doubly refracting crystal, whereas there is little or no such change in the case of true clay slates of the normal granular type containing much kaolin and very little mica.[3]

Micaceous luster is not a satisfactory criterion, for some slates, like those from Monson, in Maine, are almost lusterless and yet possess a brilliant aggregate polarization and are very sonorous. They are mica slates (phyllite slates), as are the slates at Brownville, in the same State, which have a micaceous luster.

An interesting transition from a shale to a mica slate, described on page 104, occurs at Lehigh Gap, Pa. The new muscovite (sericite) has begun to form across the bedding of the shale without as yet any change of orientation in the clastic particles. In a specimen of shale from Rensselaer County, N. Y.,[1] the incipient alignment of clastic muscovite across the bedding is well shown in thin section, and slip cleavage seems about to be set up. Some specimens of clay slate from Martinsburg, W. Va., possess fissility without any matrix of muscovite whatever, but others show the beginning of slaty cleavage by a faint aggregate polarization. These cases suffice to show that all transitions from a shale to a clay slate and to a mica slate occur.

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[1] Experiments on schistosity and slaty cleavage: U. S. Geol. Survey Bull. 241, p. 21, 1904.

[2] Rock cleavage: U. S. Geol Survey Bull. 239, p. 138, 1905.

[3] Sorby, H. C., On the structure and origin of noncalcareous stratified rocks: Geol. Soc. London Quart. Jour., vol. 36, p. 76, 1880.

While it is supposed that mica slate is the product of a less intense metamorphism than schist[2]—and it is also assumed that the process by which slaty cleavage was produced was marked by great uniformity and also took place slowly—there are as yet neither observations nor experiments for a perfectly satisfactory reply to the following questions: Why should one part of a sedimentary formation have been altered into roofing slate and an adjacent part of the same into schist? Would continued metamorphism transform a roofing slate into a schist? Was schist of sedimentary origin at one stage roofing slate? Why should metamorphism begin in some shales by the formation of slip cleavage leading to schist and in others by slaty cleavage?

As to the mineral constituents of slate, Sorby gives the average size of the scales of sericite[3] in the best Welsh slates as one two-thousandth of an inch in breadth by one six-thousandth in thickness.[4] Scattered about among the meshes of the muscovite are minerals which extinguish irregularly. Chief among these is quartz, mostly in clastic grains, sometimes formed in place or in lenses of chalcedony. This secondary quartz may attach itself to the quartz fragments or to the various other minerals to be named. Next in importance is a chloritic mineral, dichroic (light yellow, dark green), polarizing from a Prussian or plum blue to a violet or olive when the section is transverse to the scale, but remaining dark between crossed nichols during a complete revolution when the section is parallel to it. These scales are usually intergrown with lamellæ of muscovite or in places of biotite. Some lie transverse to the cleavage and parallel to the grain, and others lie parallel to the cleavage.[5] Chlorite and quartz may make up minute lenses with their long axes parallel to the cleavage, or chlorite surrounded by sericite makes lenses with their long axes in the grain direction. Some of these scales of chlorite contain needle-like crystals, probably rutile, crossing one another at angles of 60° and 120°. (See p. 102.) This chloritic mineral is regarded as of secondary origin. Rutile needles are generally but not invariably present, and in great abundance.[1] This mineral occurs also in irregular masses 0.05 millimeter or less in diameter, consisting of a network of prisms forming angles of 60° and 120° (sagenite twins), as at Peters Creek, Lancaster County, Pa., at Bremo, Va., and in Humboldt County, Nev. (See p. 155.) Hematite occurs in very minute scales and dots and very plentifully in the reddish and purplish slates. At Esmont, Va., the hematite is specular, giving an almost metallic luster to the slate when wet.[2]

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[1] See U. S. Geol. Survey Bull. 242, Pl. II, *B*, 1904.

[2] Van Hise, op. cit., p. 894: "When the depth is not great and the mass-mechanical action is not very severe, slates are likely to form. When the depth is greater and the mass-mechanical action is severe, schists or gneisses are likely to develop."

[3] See Laspeyres, H., Sericit: Zeitschr. Kryst. Min., vol. 4, p. 224, 1880.

[4] Sorby, H. C., op. cit.

[5] See Renard, A. F., Recherches sur la [illegible] ardennais: Mus. roy. hist. nat. Belgique Bull., vol. 3, p. [illegible], Pl. [illegible] Petrographie, p. 298, 1894; and Rose, G., Über die regelmässige [illegible] aufeinander sowie mit Pennin und Eisenglanz: K. Ak[illegible]

Slate may contain also cubes, lenses, or spherules of pyrite. The spherules abound in black slates. The slate of Northfield, Vt., contains lenses of magnetic iron pyrites (Fe_7S_8). Carbonaceous matter and graphite abound in the black and dark-gray slates. Clastic grains of feldspar and of zircon are characteristic. Hemimorphic prisms of tourmaline are not unusual.

Calcite and other carbonates, particularly one of lime, iron, and magnesia, are likely to be evenly disseminated in rhombs and plates. Rarely calcite fossils appear, as at Arvonia, Va. Rhodochrosite ($MnCO_3$) probably also occurs. (See p. 91.) The following have also been identified: Ottrelite, staurolite, garnet, andalusite, sphene, anatase, biotite, hornblende, epidote, apatite, gypsum, magnetite, limonite, pyrophyllite, and talc.

Many slates are speckled with minute protuberances which under the microscope resolve themselves into the lenses just referred to—so-called "eyes" or "knots." Instead of consisting of chlorite and quartz, or of these and carbonate, they may consist of an octahedron of magnetite partly surrounded by quartz and that entirely by chlorite.[3] This quartz is then regarded as a later infiltration into a cavity formed between the magnetite and the chlorite by pressure. Others consist of chlorite surrounded by calcite and that by quartz.[4]

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[1] On these see Zirkel, F., Ueber die mikroskopische Zusammensetzung von Thonschiefern und Dachschiefern: Poggendorff's Annalen, vol. 144, p. 319, 1891; Van Werveke, Neues Jahrb., 1881, vol. 1, p. 178; Sauer, A., idem, pp. 227-238; Cathrein, A., Ueber das Vorkommen mikroskopischer Zirkone und Titan-Mineralien in den Gesteinen, Würzburg, 1884; Kalkowsky, E., Elemente der Lithologie, p. 257, 1886, Sorby (op. cit., p. 68) gives the diameter of the slate needles as less than $\frac{1}{25000}$ inch.

[2] Renard gives the size of the granules of Fe_2O_3 as 0.020–0.005 millimeter (op. cit., vol. 3, p. 234). See also his Pl. XII, fig. 2, of purple and green slate, in same volume. J. Gosselet (Études sur l'origine de l'ottrelite: Soc. géol. du Nord Ann., vol. 15, pp. 188–189, Lillie, 1888) describes hematite as occurring in three forms in the reddish slates: (1) In irregular grains 0.01 to 0.02 millimeter or less; (2) in scales with a bluish steel-like luster under a mixture of reflected and transmitted light; (3) in minute granules which are always red—brick-red under reflected light.

[3] See Geinitz, E., Der Phyllit von Rimogne in der Ardennen: Min. pet. Mitt., new ser., vol. 3, also Renard, A. F., op. cit., vol. 2, pp. 133 et seq. and Pl. VI, 1883.

[4] Renard, A. F., op. cit., p. 248.

The slates of Esmont, Va., have lenses of carbonate, chlorite, quartz, and muscovite radially arranged along the cleavage foliation.

Others have a central crystal of pyrite instead of magnetite,[1] or the pyrite may have been changed to limonite.[2] Still others consist of chalcedony surrounded by chlorite scales,[3] or of quartz surrounded by radial plates of muscovite,[4] or of biotite surrounded by quartz. (See p. 80.) These lenses may, as in the Peach Bottom slate (p. 111), be so minute as not to result in any visible speckling of the surface, and they may consist of crystals of andalusite surrounded by chlorite, quartz, or muscovite, the orientation of the lens being different from that of the crystal. These crystals of andalusite may have quartz on one side and muscovite on the other.

Finally, the discoloration once attributed by Bischof to the hydration and oxidation of a ferrous oxide has been shown to be due, in some slates at least, to the alteration of a ferrous carbonate to limonite, and it is thought to be probably due to this in most slates. (See pp. 55, 140.)

The presence of kaolin is, of course, to be assumed in all clay slates and also in all mica slates in which the micasization of the matrix is incomplete. Its presence in minute quantities in those mica slates which have little or no luster, like the slates of Monson, Maine, and probably the slates of Lehigh and Northampton, Pa., may be suspected but not demonstrated.

Leaving out the rarer and less significant constituents and basing his estimates on the chemical and microscopic analyses of the principal varieties of slate from the French Ardennes, Renard computes the mineral percentages as follows:

Percentages of minerals in slates of Ardennes, France.

Mineral.	Purple.	Green.	Bluish black.	Grayish green.
Muscovite (sericite)	40.69	39.54	37.75	37.97
Chlorite	7.75	5.81	12.55	17.99
Quartz	40.41	45.78	40.58	30.97
Hematite	6.23	2.90	4.81	....
Rutile	1.55	1.04	....	1.44
Limonite	....	....	....	3.09

In round numbers this amounts to—

Muscovite	38–40
Chlorite	6–18
Quartz	31–45
Hematite	3– 6
Rutile	1– 1½

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[1] See Harker, Alfred, on "eyes" of pyrite and other minerals in slate: Geol. Mag., dec. 3, vol. 6, No. 103, p. 396, London, Sept., 1889.

[2] Loretz, H., Ueber Transversalschieferung [illegible]. (For full titles of papers and works cited see Bibliography, pp. [illegible].)

[3] Mallard, E., Sur l'examen microscopique [illegible] Soc. min. France Bull., vol. 3, No. 4, p. 101, 1880.

[4] Zirk

Renard[1] calls attention to the fact that the green slates of Fumay, in the Ardennes, contain 4 per cent more SiO_2 than the purple ones and about 3½ per cent less Fe_2O_3.

Rosenbusch,[2] in comparing 18 analyses of clay slates from different parts of Europe, calls attention to the strikingly characteristic preponderance of the MgO as compared with the CaO, along with a uniformly high percentage of iron oxides and of Al_2O_3, and also to the like preponderance of the K_2O over the Na_2O, which he explains thus:

> Clays and clay slates constitute the finest mechanical detritus from quartz-feldspar rocks; whatever silicates of lime they contain was removed as a soluble bicarbonate and for this reason very little lime-soda feldspar can occur in such a detritus.

While there has been substantial agreement as to the general microscopic and chemical character of roofing slates, there have been questions as to the origin of some of their constituents. Is the muscovite (sericite) which makes up from a third to a half of the mica slates the product of the metamorphism of argillaceous material, or are these shredlike scales the result of the disintegration of some micaceous rock, the effect of pressure having been simply to bring the shreds into parallelism and to mat them together? A shale under the microscope shows a considerable amount of apparently clastic muscovite in scales of various sizes with more or less arrangement in the direction of the bedding. Sorby regarded the micaceous mineral of slates as formed in place by an alteration of partly decomposed feldspar, yet he admitted that the structure was just such as would result from the deposition of material sorted by gentle currents and subsequently compressed. The chlorite he considered as undoubtedly secondary.[3]

Rosenbusch wrote:

> Of course the material of clay slates was mechanically brought together, but the mineral constituent of that part which is mainly micaceous and without feldspar was certainly the result of metamorphic processes which were intimately connected with dynamic geologic processes.[4]

Hutchins expressed his conclusions thus:

> This fine mixture of biotite, muscovite, kaolin, the minutest waste of feldspar, and in less degree of quartz, and probably other substances, under the joint action of pressure, warmth, and mineral solutions, gives rise to various decompositions and recombinations which result, among other things, in the formation of new mica, with the separation of titanic acid in the form of rutile. Into these reactions, whatever may be their exact course, even the muscovite in very fine state of division appears to enter; and there is good reason to conclude that in fine-grained sediments of suitable composition, exposed long enough to the necessary conditions as to pressure, tempera-

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[1] Op. cit., vol. 2, p. 147, 1883.

[2] Elemente der Gesteinslehre, p. 424.

[3] Sorby, H. C., On the structure and origin of noncalcareous stratified rocks: Geol. Soc. London Quart. Jour., vol. 36, pp. 67-77, 1880.

[4] Neues Jahrb., 1881, vol. 1, p. 399.

ture, and percolation of solutions, an almost complete regeneration of the "paste" to mica can and does take place, and that this regenerated material, under intenser dynamometamorphic action, is converted into some of the forms of micaceous slates known to us. The mica so formed is probably what in its more advanced stages of development is often known as sericite.[1]

As slates are evidently derived from the waste of granitic rocks, this material must have contained clastic mica, as do the shales, and wherever the feldspar of the granite or gneiss had previously been sericitized such sericite must have found its way into the sediments and into the slate without very great loss by decomposition. As a matter of observation, fine-grained mica slates do contain scattered scales of muscovite apart from the matrix, which may be of clastic origin, but the micaceous matrix of mica slate is regarded as mainly of metamorphic origin.

A question has also been raised as to the origin of the rutile needles. Roth[2] is decidedly of the opinion that they belong to the original sediment. Thürach,[3] Pfaff,[4] and Credner[5] find an abundance of them in clay. Rosenbusch[6] states that while zircon and apatite bear traces of their clastic origin, such traces are entirely absent in both the rutile and the tourmaline. It will be noticed in looking over the 62 microscopic analyses of roofing slates made for this volume by the writer that the abundance of these needles varies greatly. In some very crystalline slates (Peach Bottom slate of Pennsylvania and the slates of Penlan, Va., and of Maine) they are hard to find, and in some less crystalline slates (those of Arkansas and Vermont) they are very abundant.

The sizes of the mineral particles and the numerical abundance of some of them, as determined during the microscopic study of all the roofing slates described in this bulletin, are here summarized. The dimensions are given in millimeters.

Quartz, grains—0.013 to 0.1 by 0.004 to 0.03 (exceptionally 0.347 long).

Feldspar (plagioclase), grains—up to 0.047 by 0.052.

Muscovite (sericite) of matrix—thickness down to 0.00017, length from 0.006 to 0.06 and over.

Biotite, scales—up to 0.085 by 0.047 (exceptionally 0.2 by 0.09) and numbering up to 63 per square millimeter.[7]

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[1] Hutchins, W. M., Clays, shales, and slates: Geol. Mag., vol. 7, p. 317, 1896.

[2] "Doubtless some of the constituents are of secondary origin (as quartz, pyrite and the products of its oxidation, calcite, hematite, and limonite, gypsum), but the evidence of the secondary origin of the rutile needles does not seem to me convincing. Unstratified sands also contain a series of minerals."—Allgem. chem. Geologie, vol. 2, p. 586, 1887.

[3] Thürach, H., Ueber das Vorkommen mikroskopischer Zirkone und Titan Mineralien in den Gesteinen: Phys.-math. Gesellsch. Wurzburg Verh., N. F., vol. 18, No. 10, 1884.

[4] Pfaff, F., Petrographische Untersuchungen über die eocenen Thonschiefer der Glarner Alpen: K. k. Akad. Wiss. Munich Math.-phys. Classe Sitzungsber., vol. 10, p. 479, 1880.

[5] Credner, G. R., Die Krystallinischen Gemengtheile gewisser Schieferthone und Thone: Zeitschr. ges. Naturwiss., Halle, 1874.

[6] Elemente der Gesteinslehre, p. [illegible], 1898.

[7] The square millimeter given concerns only the thickness of the thin section.

Chlorite, scales—0.047 to 0.17 by 0.006 to 0.1 (exceptionally 0.38 by 0.25) and numbering up to 380 per square millimeter.

Carbonate, rhombs—0.002 to 0.065.

Rutile "needles"—0.0017 to 0.095 by 0.0006 to 0.006 and averaging in certain Vermont slates about 65,000 per square millimeter, or about 40,000,000 per square inch. In a slate from Lancaster County, Pa., groups of intergrown rutile crystals measure up to 0.04 in diameter and average about 15 per square millimeter.

Pyrite, lenses and distorted cubes—0.002 to 0.094 by 0.47 (rarely 0.6 by 0.1) and numbering up to 1,160 per square millimeter.

Pyrite, spherules—0.0017 to 0.027 and numbering up to 18,000 per square millimeter.

Magnetite, distorted octahedra—0.009 to 0.14 by 0.02 (rarely 0.17 by 0.04) and numbering up to 49 per square millimeter.

Hermatite, dots—0.0004 to 0.01.

Tourmaline, prisms—0.005 to 0.076 by 0.001 to 0.009.

Andalusite, prisms—0.008 by 0.001 to 0.11 by 0.03 (exceptionally 0.2 by 0.02) and numbering up to 310 per square millimeter.

Lenses of chalcedonic quartz and rhodochrosite: 0.32 by 0.15 (exceptionally 1 millimeter long).

Lenses of biotite and quartz—up to 0.565 by 0.14 (rarely 1 by 0.075).

Lenses of pyrite and quartz—up to 0.75 by 0.12.

Lenses of carbonate, chlorite, quartz, and muscovite measure from 0.2 to 2 in length and up to 0.7 in width and number up to 4 per square millimeter.

Lenses of chlorite or quartz or muscovite or combinations of them, containing each an andalusite prism and measuring 0.04 to 0.25 by 0.04 to 0.1.

As the mineral constituents of aqueous sedimentary slates were either (1) derived from older rocks and deposited either as mechanical sediments or chemical precipitates, or (2) formed during metamorphism, or (3) derived from marine organisms, they are to be classified as follows:

Classification of mineral constituents of slates.

Clastic.	Clastic or authigenous.	Authigenous.	Organic.
Quartz grains. Feldspar grains. Zircon grains. Muscovite scales. Kaolin. Apatite. Magnetite? Carbonates, granular.	Rutile needles. Tourmaline.	Quartz, chalcedonic. Quartz, vein. Muscovite (sericite). Biotite. Chlorite, interleaved with muscovite or biotite. Pyrite, pyrrhotite. Magnetite. Hematite. Carbonates of lime, iron, magnesia. Carbonate of manganese. Andalusite. Barite. Gypsum. Talc.	Carbonaceous matter. Graphite. Calcite (fossils).

Of course these secondary or authigenous minerals were merely new combinations, sometimes in crystalline form of clastic minerals. Thus the hematite originated in sedimentary limonite. The andalusite ($Al_2O_3.SiO_2$) probably originated in kaolin.

The principal elements in roofing slates, as determined by the chemical analyses given in the section on the chemistry of slate (p. 50), are to be attributed to the mineral constituents in the following way:

SiO_2 to quartz, muscovite, biotite, feldspar, chlorite, tourmaline, andalusite, zircon, and kaolin.

TiO_2 to rutile.

Al_2O_3 to muscovite, biotite, feldspar, chlorite, tourmaline, andalusite, and kaolin.

Fe_2O_3 to hematite, magnetite, muscovite, and biotite.

FeO to chlorite, magnetite, carbonate, and biotite.

MnO to rhodochrosite.

CaO to plagioclase, calcite, carbonate of lime, iron, magnesia, and apatite.

BaO to barite and some silicate.

MgO to chlorite, biotite, and carbonate.

K_2O to muscovite and orthoclase.

Na_2O to muscovite and plagioclase.

Li_2O to tourmaline.

H_2O to muscovite, chlorite, limonite, and kaolin.

P_2O_5 to apatite.

CO_2 to calcite, rhodochrosite, and carbonate of lime, iron, and magnesia.

FeS_2 to pyrite.

SO_3 to barite and gypsum.

C to graphite and coaly matter.

Zr_2O to zircon.

The mineral sources of the nickel, cobalt, chromium, vanadium, and ammonia detected by Dr. Hillebrand in the slates of Vermont and New York have not been determined.

SPOTTED SLATES.

GENERAL CHARACTER OF SPOTS.

The spots in roofing slates have long attracted attention.[1] In the slate region of eastern New York and western Vermont many of the purple slates have green spots of circular, oval, or irregular outline. These spots locally occur only along lines of bedding and correspond to or pass into green "ribbons." In places, however, an entire bed of purple slate several feet thick is irregularly spotted throughout. Some of the red slates are also spotted. The spots are commonly circular or oval, measure from a fraction of an inch to several inches in diameter, and are of pale-green color, with or without a purple border. Some of the spots, however, have no symmetry whatever. In order, if possible, to throw some new light on this subject a few thin sections were prepared across small spots in directions parallel to and across the cleavage, and chemical analyses were made by Dr. Hillebrand of the green center of a spot from the spotted red slates, of its purple rim, and of the outer red slate.

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[1] Tyndall, John, Comparative view of the cleavage of crystals and slate rocks: Philos. Mag., vol. 12, July, 1856. Maw, George, On the disposition of iron in variegated strata: Geol. Soc. London Quart. Jour., vol. 24, p. 379, Pl. XIV, figs. 29, 31, 32, 1868. Gosselet, J., Les schistes de Fumay, Soc. géol. Nord Ann., vol. 11, pp. 63-86, Lille, 1884; L'Ardenne, p. 35, 1888. Geikie, Archibald, Text-book of [illegible] vol. 1, p. 451 (2), 1893. Zirkel, Ferdinand, Lehrbuch der Petrographie: 2d ed., vol. 3, pp. [illegible]

MICROSCOPIC ANALYSES OF SPOTS.

An elliptical green spot, 1 by ¾ inch, in purple Cambrian slate from the Lake Bomoseen Slate Co.'s quarry at Cedar Point, Castleton, Vt., in a section cut parallel to the cleavage, shows, in the green part, muscovite scales lying in all directions, large chlorite scales, quartz fragments, carbonate rhombs, and a few irregular spherules of pyrite. In the center is some opaque noncalcareous matter, partly surrounded by an aggregation of spherules of pyrite in a cloud of rutile needles. There are also cracks filled with secondary sericite. In the surrounding purple rim the same elements recur, but the pyrite is much more abundant, measuring up to 0.021 millimeter. There are also many dots of Fe_2O_3 from less than 0.003 to 0.009 millimeter, and rutile needles up to 0.012 millimeter in length.

An elliptical green spot, 3 inches long, with a purple rim, in Ordovician red slate from the National Red Slate Co.'s quarry north-northwest of Raceville, N. Y. (specimen D. XIV, '95, 397a), when cut transversely to the cleavage, measures half an inch in thickness and shows a black streak 1 inch long in the center. The central streak consists of strings of minute irregular lenses of cryptocrystalline quartz and possibly carbonate of manganese (rhodochrosite) containing spherules of pyrite. The green part consists of a mass of fibers of muscovite, which polarize as one mineral, with much carbonate and many lenses like those in the center, and also quartz grains. In the purple rim there is a decrease of carbonate and the hematite fragments begin to appear, and in the surrounding red slate hematite becomes still more abundant.

A green spot in Ordovician red slate (D. XIV, '95, 201c), from the Empire Red Slate Co.'s quarry, 1 mile north of Granville, N. Y., cut parallel to the cleavage, shows slate needles (TiO_2) up to 0.043 millimeter long, carbonate rhombs up to 0.030 millimeter, chlorite scales up to 0.030 millimeter, angular quartz grains up to 0.039 millimeter, and prisms of tourmaline up to 0.021 by 0.002 millimeter. The surrounding red slate, that of analysis K (p. 92), is described on page 91.

Another spot, almost circular, 0.44 inch in diameter, from a piece of red slate (D. XIV, '95, 201 l) from the same quarry, cut parallel to the cleavage, shows a central dot 0.03 inch in diameter, consisting mainly of carbonate and of a dense brown material. About this is a zone about 0.1 inch wide, of elliptical shape, consisting of carbonate, with some fibrous quartz along the margin. Then comes a zone, 0.08 inch wide, of green slaty material, containing angular quartz grains, muscovite scales, rutile needles, nodules of pyrite, and thinly disseminated areas and rhombs of carbonate; then a very narrow zone made up entirely of carbonate and pyrite. Outside of this, another zone of green slate, 0.08 inch wide, like the first, but with very little carbonate. The angular quartz grains measure up to 0.030 millimeter. There are also slender tourmaline prisms. Outside of all comes the red slate, full of Fe_2O_3 pigment. Chlorite was not detected in the green zones, but it may be present in minute scales.

CHEMICAL ANALYSES OF SPOTS IN RED SLATE.

The specimen (Q, R) analyzed by Dr. Hillebrand came from the same quarry (near Raceville) as the large spot described above. It was a green spot with purple rim, in red slate. The analysis of the red slate M, on page 92, is repeated for comparison.

Chemical analyses of spotted red slate.

	M	Q	R		M	Q	R
Silica (SiO_2)	63.88	64.59	65.44	Magnesia (MgO)	5.37	5.12	4.92
Titanium dioxide, rutile (TiO_2)	.47	.51	.52	Potassa (K_2O)	3.45	3.70	3.57
Alumina (Al_2O_3)	9.77	10.23	9.38	Soda (Na_2O)	.20	.23	.22
Ferric oxide (Fe_2O_3)	3.86	1.79	1.09	Lithia (Li_2O)	Str. tr.	Str. tr.	Str. tr.
Ferrous oxide (FeO)	1.44	1.19	1.06	Water below 110° C. (H_2O)	.27	.28	.25
Manganous oxide (MnO)	.21	.26	.32	Water above 110° C. (H_2O)	2.48	2.29	2.10
Nickelous oxide (NiO)	Trace.	Trace.	Trace.	Phosphoric oxide (P_2O_5)	.08	.08	.08
Cobaltous oxide (CoO)	Trace.	Trace.	Trace.	Carbon dioxide (CO_2)	5.08	5.84	6.55
Lime (CaO)	3.53	4.07	4.53	Pyrite (FeS_2)	Trace.	Trace.	.04
Baryta (BaO)	.05	.05	.06		100.14	100.23	100.13

M (=D. XIV, '95, 397 *a*), Red slate, 1 mile north-northwest of Raceville, in Granville, Washington County, N. Y., about a spot; Q, purple rim of the spot; R, green portion of the spot.

Dr. Hillebrand adds this observation:

Calculation shows that with no CO_2 there would be only enough CaO for the P_2O_5, and, further, that the result would be no MnO. How much FeO, if any, exists as carbonate is not indicated. If, after allowing for apatite, for $MnCO_3$, and $CaCO_3$, the remainder of the CO_2 is charged to MgO, we find the proportions shown in the columns below. [See p. 58.]

	M	Q	R
CaO_3	6.14	7.11	7.93
$MgCO_3$ (in part $FeCO_3$)	4.22	4.77	5.36
$MnCO_3$	.38	.47	.57

DISCUSSION OF THE SPOTS.

From Dr. Hillebrand's analyses it would appear that there is a decrease of the carbonates of lime and manganese and magnesia and of silica and rutile from the center of the spot outward and an increase of Fe_2O_3 in the same direction.

The main results of the microscopic and chemical analyses
even as to the relative amount of pyrite. The difference in co
the green to purple and red is manifestly due to the diffe

amount of hematite. Pyrite, rutile, carbonate, and tourmaline are more abundant within the spots than without them.

Certain green fossil impressions in purple slate at Middle Granville, N. Y., may throw some light on the origin of these spots. In this locality the effect of organic matter, whether the carbonaceous matter of the lining of an annelid boring or matter from a marine alga, has been to diminish the quantity of Fe_2O_3 in the slate and possibly to increase the amount of chlorite.[1] Gosselet regards the spots as the result of the reduction of the hematite (Fe_2O_3) by decaying organisms to the ferrous oxide (FeO) and its removal as an organic salt or as a carbonate. He observes that the green spots in purple tiles wear less readily than the rest of the tile, because they contain more quartz, and this SiO_2 he attributes to infiltration.[2]

In the spots from the slates of New York and Vermont examined by Dr. Hillebrand and the writer the marked decrease of Fe_2O_3 is accompanied by a marked increase of carbonate of lime, iron, and manganese and of SiO_2, also by a slight increase, in some of the thin sections at least, of FeS_2. Carbonates are also characteristic of the spots in some European slates.[3] The increase of the carbonates may be directly connected with the production of CO_2 by decaying organisms and the consequent decrease of the Fe_2O_3. Not impossibly the organism may have had a calcareous exoskeleton which was dissolved and then redeposited as crystalline $CaCO_3$. The infiltration of SiO_2 and the formation of chalcedony may be purely secondary, and likewise the deposit of FeS_2, or there may have been some precipitation of FeS_2 about the decaying organism, as seems to have occurred in some fossiliferous sediments. At any rate, the rim of intermediate composition would be the zone in which chemical reaction was less effective. In view of all these facts and indications the spots may be safely regarded as probably produced by chemical changes in the sediments consequent upon the decay of organisms. If this is the correct view, the green ribbons, which traverse both purple and red slate, would correspond to small deposits of decomposing organic material that effected similar changes in the Fe_2O_3 of the argillaceous sediments. Where a bed of quartzite forms the center of such a ribbon quartzose sedimentation must have taken place also, and possibly this may have been the very condition which proved favorable to marine life.

Not to be confounded with the spots described above are certain white or whitish spots on the cleavage surfaces of some slates (Northfield, Vt., and Penlan, Va.) measuring up to 2 inches in diameter and consisting of a fine film of calcite, with or without other carbonates, deposited by water percolating along the cleavage, the water, originally acid, having dissolved the carbonate from the slate itself. The cause of these spots is analogous to that of some of the minerals found coating the joint planes in slate. (See p. 42.)

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[1] See Tyndall, Maw, Gosselet, Geikie, and Zirkel, as indicated by titles given in footnote on p. 23.

[2] Maw (loc. cit.) had analyses made of dark-greenish ribbons in the Welsh blue slates, and found that the ribbons contained 6 per cent more SiO_2, 7 per cent more Al_2O_3, 4.5 per cent more MgO (= 7 times as much), but 4 per cent less Fe_2O_3, 1 per cent less FeO, and 3.5 per cent less K_2O than the adjacent blue beds. Under the microscope the green ribbons showed more feldspar and chlorite. Maw attributes these differences to change in sedimentation.

[3] Zirkel, Ferdinand, loc. cit.

IGNEOUS SLATES.

Some very remarkable slates of igneous origin are the green slates from the English lake district (Buttermere, Tilberthwaite, etc.), which consist of volcanic ash and which have long been known in England as excellent roofing material. These have been chemically and microscopically analyzed and described [1] and were found to consist chiefly of chlorite, calcite, quartz (mostly secondary), and muscovite, but to contain also andesitic lapilli, feldspar, garnets, sphene, and anatase. Slate needles and tourmaline are conspicuously absent. The chemical analyses show the following important constituents:

SiO_2	50.16–54.02	FeO	5.97–7.06
Al_2O_3	11.94–17.85	CO_2	2.45–5.41
CaO	3.67– 6.46		

The CO_2 if calculated to $CaCO_3$ would give from 5.56 to 12.29 per cent of $CaCO_3$. The specific gravity ranges from 2.775 to 2.788. The percentage of SiO_2 is low, and that of FeO is near that of the "unfading green" slate of Vermont (p. 142).

Still more remarkable are the slates first described by E. C. Eckel in 1903,[2] which seem to have been formed directly from igneous rock by shearing. They show from 3 to 9 per cent less SiO_2 than the English ash slates and more than double the per cent of MgO of the European and American roofing slates of aqueous sedimentary origin, analyses of which are given under the heading "Chemistry of slate" (p. 50). These slates are fully described by Mr. Eckel on page 68.

In this connection E. B. Mathews now regards some of the slates of Maryland as at least partly of volcanic origin (p. 85), and J. E. Pogue, jr., describes a schistose slate from North Carolina as of mixed sedimentary and volcanic origin (p. 208).

STRUCTURE OF SLATE.

BEDDING.

Ordinary planes of bedding may be defined as those which are approximately parallel to the surface of the water in which the sediment was formed. If the sediment changes in character, then a horizontal bed of different material results. If, deposition being interrupted, annelids creep over the bottom or algæ decompose there, and the same kind of sedimentation is afterward resumed, then two horizontal beds of the same material will result, separated by a plane covered with trails and impressions. Some bedding planes are due to the changing size or arrangement of the particles, some may be the result of contraction in drying, and some are the effect of vertical compression. Whatever explanation may be offered for bedding, the bed is the starting point in a slate quarry, for the direction of the bed indicates (cleavage, etc., being equal) where the same quality of slate is likely to recur.

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[1] Hutchins, Maynard, The ash slates of the lake district: Geol. Mag., 1892. Reade, T. M., and Holland, Philip, The green slates of the lake district, with a theory of slate structure and slaty cleavage: [illegible] Geol. Soc. Proc. (1900-1901), 1901.

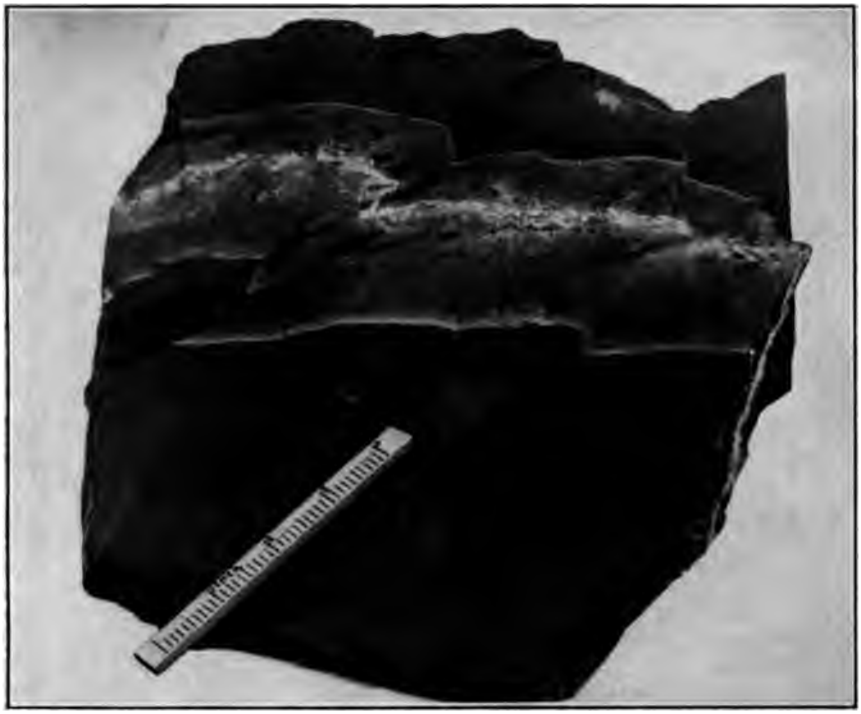
[2] U. S. Geol. Survey Bull. 225, p. 419, 1904; On a California roofing slate of igneous origin: [illegible] vol. 12, p. 15, Jan.-Feb., 1904.

In those places where folding has brought the bedding plane to the angle of inclination required by the cleavage, the unaltered sedimentary particles of the slate still retain their parallelism to the bedding—that is, cleavage and bedding are parallel—but in all other places cleavage is necessarily more or less transverse to bedding. This statement, of course, assumes that the slate beds still retain the position they had when slaty cleavage was set up in them.

Plate II, *B*, shows a ledge of green roofing slate with a cleavage striking N. 15° W. and dipping 20° E. and joints striking N. 30° E. and dipping 45° E. The upper part is a quartz sandstone or grit, with calcareous concretions containing Lower Cambrian trilobites. The direction of the axial planes of the calcareous bodies and the direction of the line of contact between the slate and sandstone show that the direction of the bedding is horizontal.

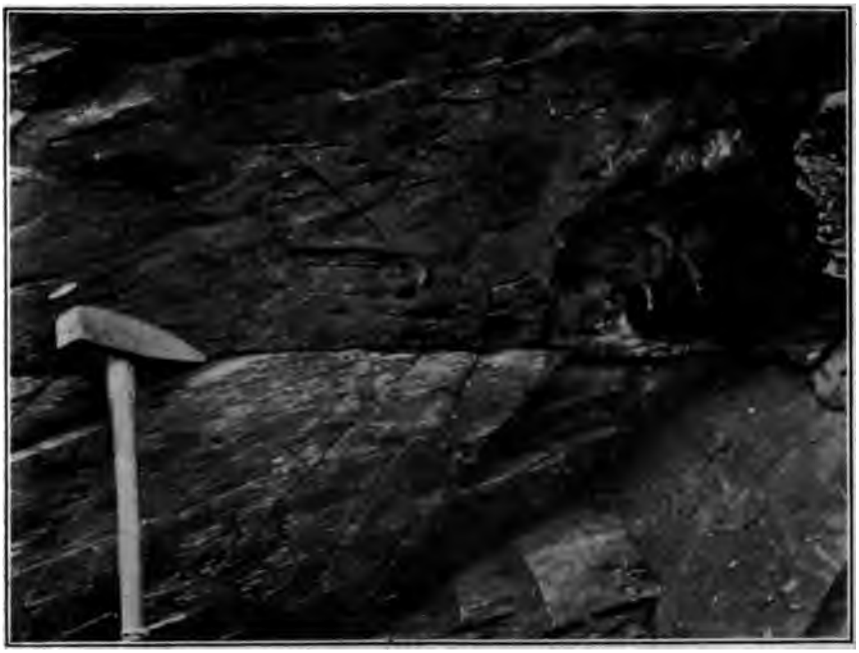
The "ribbons" of the Pennsylvania quarries (shown in figs. 9–12 and Pls. V, *B;* XIII; XIV; and XVIII) consist of small beds of quartz sandstone or grit in which the particles are held together by a calcareous and locally a sericitic cement, the original clay having gone into muscovite. These beds are also very carbonaceous (Pl. VI, *A*). Here and there the slate beds are separated, as in the Vermont and New York quarries (Pls. XXIII, XXIV), by beds of calcareous quartzite reaching several inches in thickness and consisting of grains of quartz sand cemented together by secondary quartz and calcite and other carbonates. Such beds may be but a fraction of an inch in thickness and consist mainly of carbonate, as in the syncline at West Pawlet, Vt., shown in Plate XXV. In some places bedding is indicated simply by a variation in the amount of lime in successive beds, as in the syncline at West Castleton, Vt., shown in Plate III. Here the solution of the lime by the acids of the atmosphere has etched the joint face, as it were, and the more calcareous beds thus stand back from the less calcareous beds.

Planes of bedding may be indicated by the position of fossils, as the brachiopods, crinoids, and trilobites at the Arvonia quarries in Virginia, or by bifurcating impressions, possibly made by seaweeds,



A. RED SLATE FROM QUARRIES 1¼ MILES SOUTH OF HATCH HILL, WHITEHALL, N. Y.

Whitish streak is bed of greenish dolomite, rimmed by very thin green slate, and this by purple slate, the whole an inch wide. It crosses the cleavage diagonally.



B. SANDSTONE RESTING ON GREENISH SLATE AT EDDY HILL, FAIR HAVEN, VT.

Calcareous concretions in sandstone have their longer axes parallel to the bedding. Cleavage of slate dips 20° and joints 45°. An irregular cleavage continues into the sandstone. One foot of sledge handle is in sight.

PLATE IV.

Plicated and Faulted Beds in Slate.

A. Extremely plicated bed of quartzose limestone or calcareous quartzite in Cambrian slate at Fair Haven, Vt. Natural size. The slate on both sides of the bed for half an inch is green; beyond that, purplish.

B. Extremely plicated bed of quartzose dolomite or calcareous quartzite in Cambrian slate at Fair Haven, Vt. Reduced one-half.

C. Faulted quartzite bed in slate at Meadow Slate Co.'s quarry, Fair Haven, Vt. Normal fault.

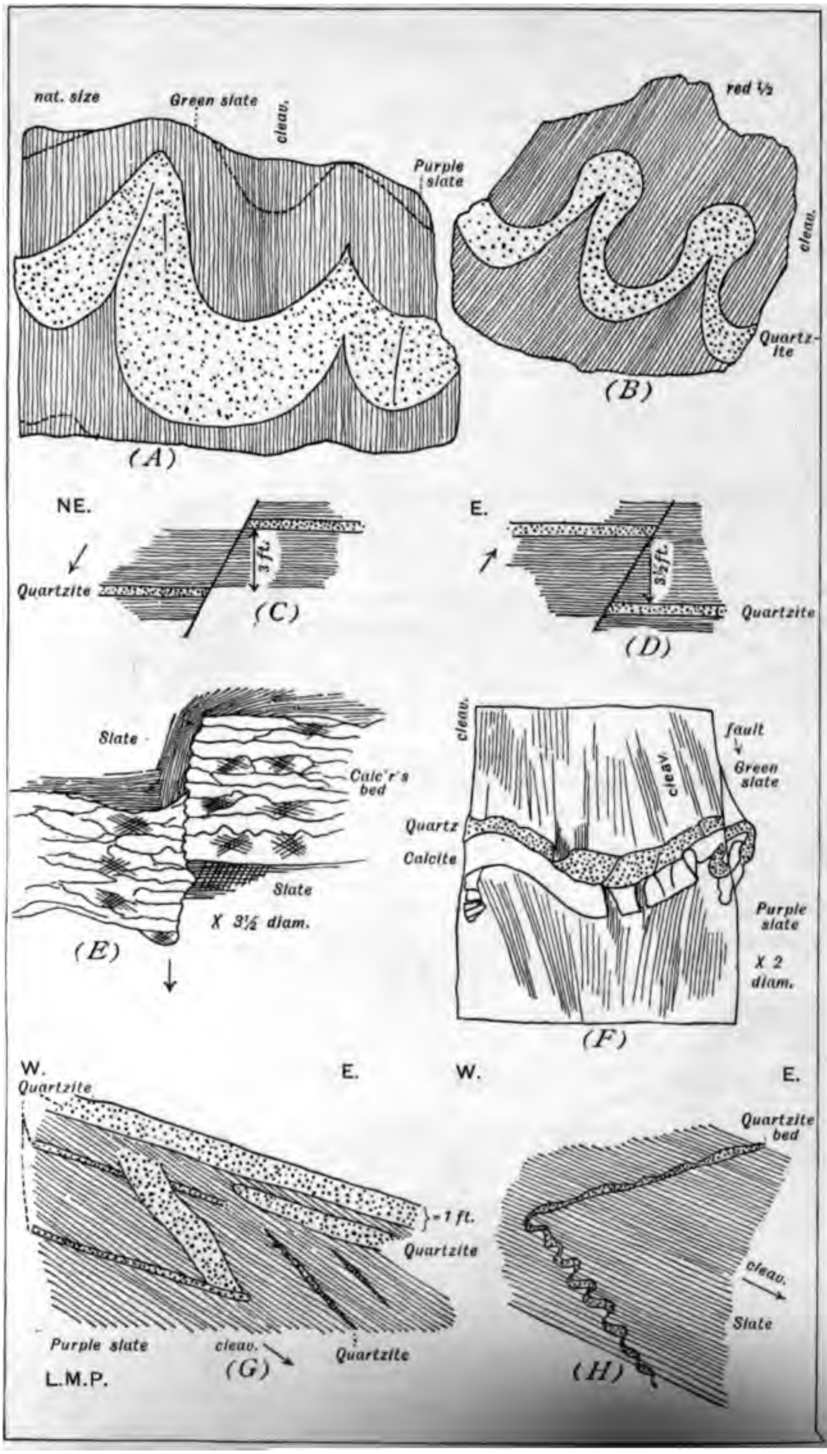
D. Faulted quartzite bed in slate at Eureka quarry, Poultney, Vt. Reversed fault.

E. Thin section of faulted calcareous bed at Pawlet, Vt., given in Plate XXIII, *D* (p. 126), showing adjustment of cleavage to faulting and production of secondary cleavage. Enlarged 3½ diameters.

F. Thin section of plicated and faulted beds of calcite and quartz separating beds of purple and green Cambrian slate at Blissville, Castleton, Vt. Enlarged 2 diameters. Both calcite and quartz beds are bordered on both sides with chlorite scales.

G. Dislocated beds of quartzite in purple Cambrian slate at old quarry about 1 mile south of West Castleton, Vt. A fragment of a bed of quartzite has been turned about into the cleavage foliation and across smaller beds of quartzite. By L. M. Prindle.

H. Plicated and folded quartzite in Cambrian slate at Fair Haven, Vt. Height, 40 feet. Minor plications somewhat enlarged.


nat. size
Green slate
cleav.
Purple slate
(A)
red ½
cleav.
Quartz-ite
(B)
NE.
Quartzite
3 ft.
(C)
E.
3½ ft.
Quartzite
(D)
Slate
Calc'r's bed
Slate
X 3½ diam.
(E)
cleav.
fault
Green slate
cleav.
Quartz
Calcite
Purple slate
X 2 diam.
(F)
W.
E.
Quartzite
= 1 ft.
Quartzite
Purple slate
cleav.
Quartzite
(G)
L.M.P.
W.
E.
Quartzite bed
cleav.
Slate
(H)

of the plicated bed of Plate XXIII, *D*. The bed here consists of calcite and vein quartz, the original calcareous sediment having been crystallized and vein quartz deposited. The diagram shows the faulting of the bed, the bending of the cleavage foliation, and the slip cleavage caused by the dislocation. The plication of some of these small beds of quartzose limestone and calcareous quartzite is extreme, as shown in Plate IV, *A*, *B*, *H*. The folding in such places seems to have been preserved only in the hard beds, while in the more plastic material of the slate on either side slaty cleavage has obscured or effaced the bedding.[1]

Plate IV, *F*, represents a plicated bed of quartz and one of calcite separating beds of purple and green slate. Under the microscope both quartz and calcite beds are bordered with chlorite scales on the outside and separated by such scales; there is also some pyrite along the edges. The cleavage of the slate is at right angles to the course of the bedding but is slightly deflected near the plicated beds. In several places the slaty material has been drawn partly into the bed.

A thin section of a small plicated bed of quartzite in the purple slate of the Cedar Point slate quarry, in Castleton, Vt., shows that the bed consists mainly of quartzite, but this contains grains of plagioclase, rhombs of dolomite, and scales of muscovite. Toward the slate there are coarse fibers of muscovite. The slate merges into the quartzite, sending out long streamers of sericite, which penetrate between the grains of quartz and calcite. The slate contains large scales of chlorite within the meshes of sericite, and these scales lie at right angles to the cleavage—that is, parallel to the course of the bed. It also contains grains of quartz. The fibrous character of the slate is apparent at the border of the quartzite bed. The significance of such a bed is that sandy material was deposited for a brief interval during the deposition of the finer material which produced the slate; there were grains of quartz and of feldspar and probably scales of mica, together with calcareous mud. Under the compression and the chemical changes which accompanied it the quartz grains were cemented into quartzite, the calcareous mud was crystallized, and the bed was plicated and became entangled with the slaty material. The slaty material itself was also somewhat plicated, and a secondary cleavage (slip cleavage) was produced in it. The plication and overturning of quartzite beds are shown on a large scale in Plate XXIV, *T*.

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[1] See Hitchcock, C. H., Second annual report on the natural history and geology of Maine, p. 285, fig. 45, 1862, where he describes a bed of strongly plicated limestone lying between unplicated beds of slate. See also the classic figure of H.C. Sorby given in his paper on the origin of slaty cleavage; Edinburgh New Philos. Jour., vol. 55, pp. 139, 140, July, 1853, which was reproduced by Tyndall in his Royal Institute lecture, and also by Phillips in his British Association report on cleavage.

Exceptionally the quartzite beds seem to have been pushed out of their normal parallelism, even without folding or faulting. Brecciation on a somewhat large scale is shown in Plate IV, *G*, from a photograph taken near the place shown in Plate XXIV, *T*.

The slate of Rockmart, Ga. (p. 73), shows very unusual ribbons, single compressed folds covering an area of the cleavage surface 10 inches square. (See fig. 1.)

In many places, however, the bed surface is simply a parting whose meanderings must be carefully followed in order to distinguish it from fractures of various kinds, as in parts of the West Pawlet syncline (Pl. XXV); or the bedding may be indicated by the weathering out of calcareous matter from the slate itself, some beds containing more of it than others, as at the syncline at West Castleton (Pl. III). The rock at West Castleton is a shaly slate, consisting of alternating light and dark gray bands—that is, beds of muscovite and chlorite scales—grains of quartz, spherules of pyrite, and some carbonate, but there is more carbonate in the gray bands than in the black ones, which contain more carbonaceous matter. Here and there is a minute bed consisting largely of calcite. This explains why the beds are so clearly and yet so delicately brought out on the joint face. The original sediments contained varying amounts of calcareous material. The carbon dioxide brought down from the atmosphere by the rain has, as it were, carried away the more calcareous parts, leaving the less calcareous parts in relief.

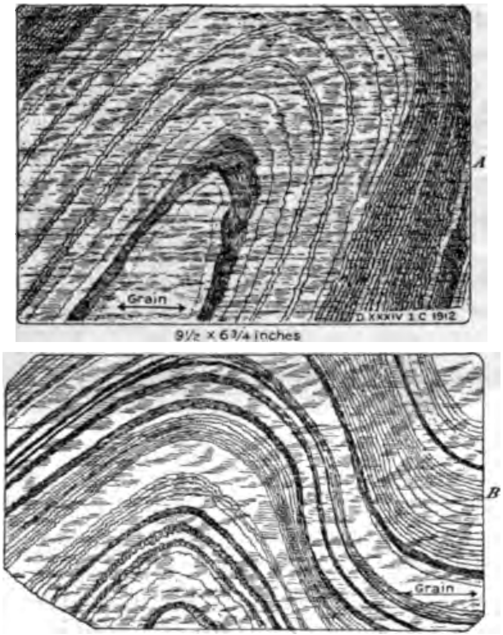
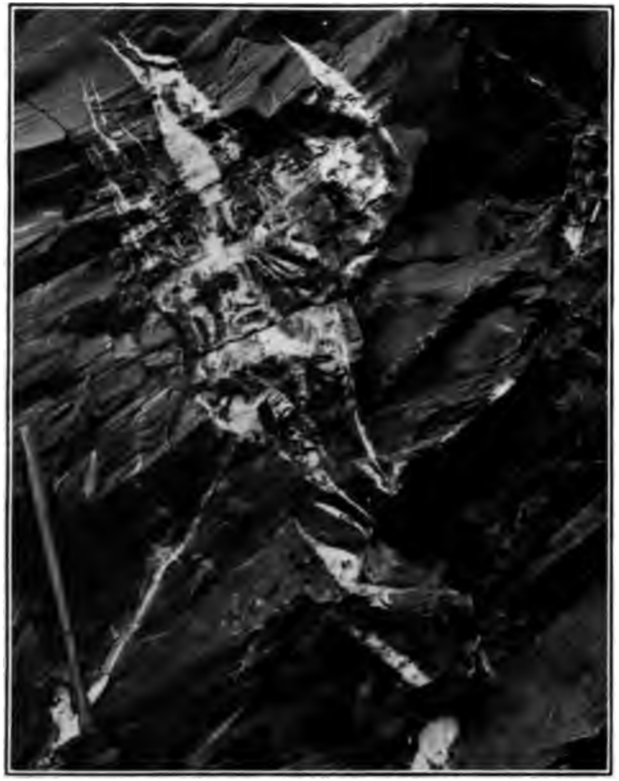


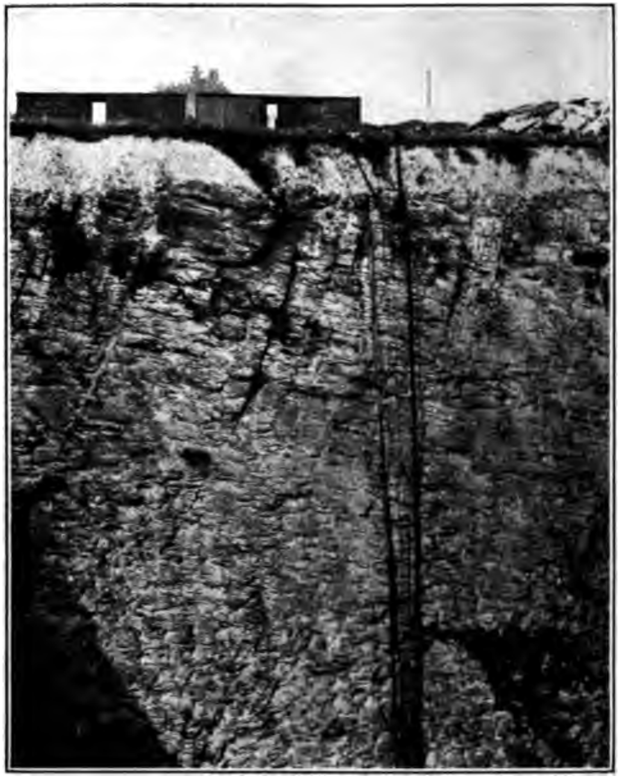
FIGURE 1.—Sketches of the cleavage surfaces of two roofing slates from the Pritchard & Davis quarry, Rockmart, Ga., showing greatly plicated bedding crossing the cleavage at a very acute angle, with the grain nearly at right angles to both. The little beds contain more quartz and carbonate than the intervening slate.

In many of the eastern New York and western Vermont quarries change of color alone is an indication of the passage from one bed to another. This change may be gradual or abrupt. But color is not an infallible guide, as the red slate may pass into the green along the



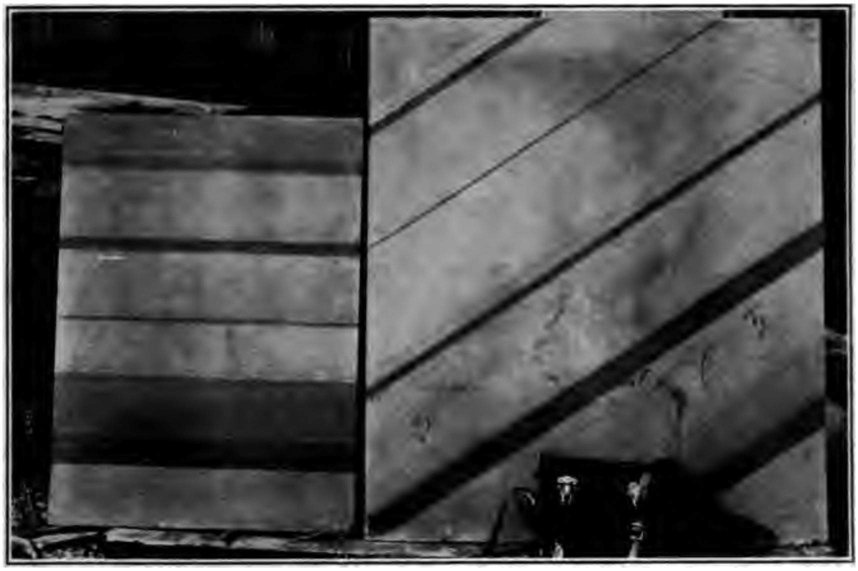
A. QUARTZ VEINS IN SLATE AT JAMESVILLE, N. Y.

Shows quartz vein of segregation crossing the cleavage of greenish slate. Sledge handle is 30 inches long.



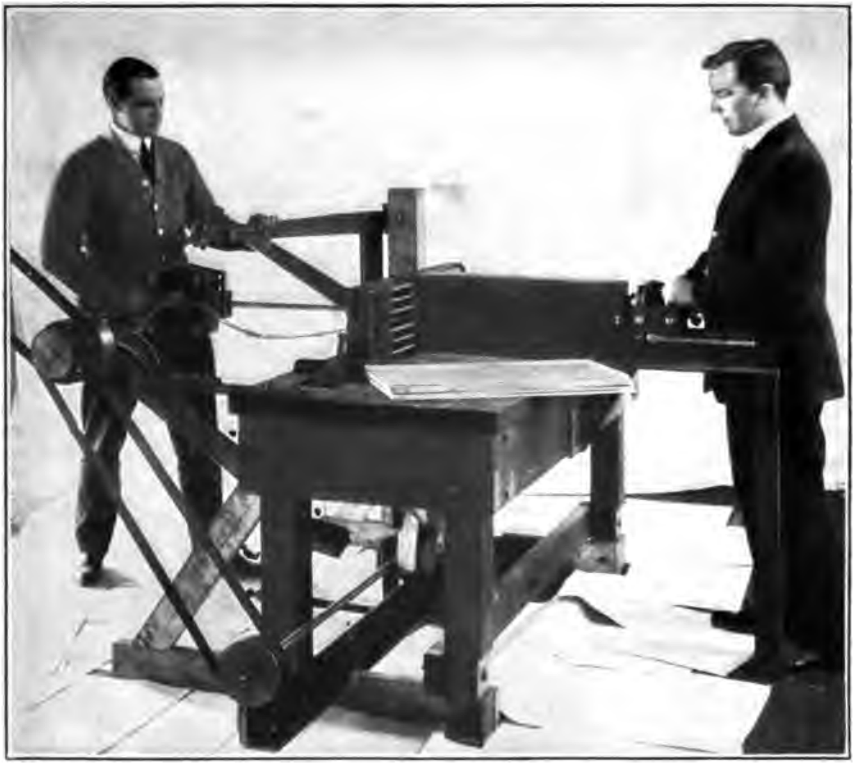
B. BEDDING AND CLEAVAGE IN PHOENIX QUARRY, WINDGAP, PA.

The more calcareous, "ribbon" beds, a little weathered at the top, curve steeply northward.



A. BLACK-BANDED GRAY SLATE FROM PHOENIX QUARRY, WINDGAP, PA.

Smoothly ground slabs showing variation in width of ribbons. Camera case 12 inches square.



B. SLATE-SPLITTING MACHINE IN OPERATION.

The wide blade of the chisel is entering the slate block.

same bed, and there is no reason why the Cambrian purple should not likewise pass into the green of the same formation.

In some places where there are no fossil impressions or intervening beds of very different material or partings or slight changes in the composition of the slate itself producing changes of color or different degrees of erodibility the course of the bedding may be made out in a thin section cut transverse to the cleavage when examined under the microscope. There may be an occasional arrangement of the particles parallel to the original bedding or an extremely minute bed of other material, or lines of different particles may cross the cleavage foliation. Plate VII, *C*, illustrates slates of this kind.

Gosselet[1] gives some remarkable instances of intense and complex folding of beds of slate on a large scale. These great folds are very acute and overturned. In some places shafts have been dug through other rocks in order to reach underground portions of synclines and anticlines and quarry the slate. Slate quarrying in the Ardennes thus resembles coal mining in a region of intense folding. The great flat slate syncline of Bangor, Pa., is shown in Plates XIII and XIV.

SLATY CLEAVAGE.

The causes and the structure of slaty cleavage have already been discussed under the headings "Origin of slate" and "Petrographic characters."

Relation to bedding.—In most slate regions cleavage is not coincident with bedding. Its relations to bedding are illustrated in figs. 9–12 and Plates III; V, *B;* XII–XIV; XVII; XVIII; XIX, *A;* XXIII–XXV. The lowest inclination of slaty cleavage in slate districts visited by the writer is 5°–10° and occurs in Pennsylvania. (See Pls. XIII, XIV.)[2] The lowest in the eastern New York and western Vermont belt is 20°. Where the cleavage approaches horizontality within 5° to 10° its position is probably due in part to a secondary crustal movement, and the local curvature of both joints and cleavage in the Pennsylvania region also points to such a movement.

Amount of compression in the formation of slaty cleavage.—Sorby calculates that on a small bed of intensely plicated sandy slate, inclosed in ordinary slate, the amount of shortening by plication was about 75 per cent, and reasons that the clayey material of the slate itself must therefore have been compressed to the same extent. This is the only way in which the amount of compression actually suffered by a mass of slate could be computed. But this calculation does not take into consideration the elongation of the slate in the shearing.

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[1] Gosselet, J., L'Ardenne, p. 41, fig. 7 (Les rapports de Ste. Marie avec les Trésfossés), 1888; Les schistes de Fumay, Pl. III, fig. 1 (Bond dans les schistes de Fumay), 1884.

[2] See also U. S. Geol. Survey Thirteenth Ann. Rept., pt. 2, Pl. XC, 1893, showing a slate quarry near Lebanon, N. Y., with cleavage dipping 10°.

Relation of cleavage dip to dip of inclosing hard beds.—Gosselet brings out the fact that where a bed of slate lies between beds of a hard rock like quartzite there is a constant geometric relation between the cleavage dip of the slate and the dip of the beds of quartzite. The same thing is true, as he shows, in the horizontal relations between the strike of the cleavage, that of the quartzite bed, and the direction of movement:

> Unless the ancient shore yielded to the pressure from the south the lower beds must have had a tendency to rise against that obstacle, to slide as a wedge between the obstacles and the overlying beds. The slaty material inclosed between the two beds of quartzite is thus pushed upward in a direction which is the component between a vertical line (that is, vertical to the horizon) and the oblique movement of the wall (that is, along the surface of the slate bed). Cleavage will be developed along that component, and we actually find that it dips 40° while the bed dips 27°.

Gosselet's figure is here repeated (see fig. 2) with the construction added.[1] The gist of his statement is that if we knew the dip of the hard beds on either side of a bed of slate we could foretell the cleavage dip of the slate. This, however, would be applicable only where no secondary disturbance of sufficient force to affect the relations had occurred.

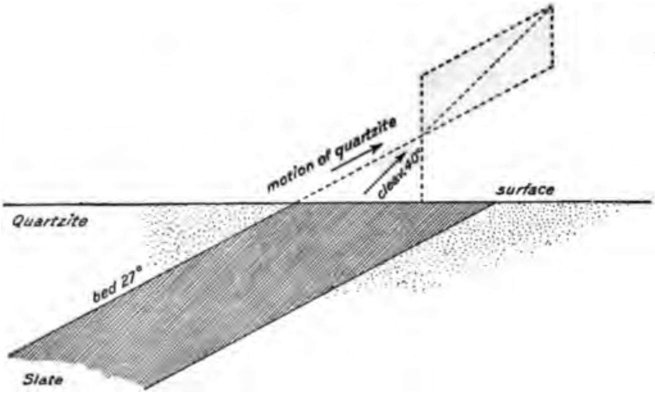

FIGURE 2.—Diagram showing relations of cleavage of slate to dip of inclosing hard beds. After J. Gosselet.

Relations of cleavage to axes of folds.—Some pre-Cambrian and Paleozoic schist masses have two transverse systems of folding, which within small areas interfere with one another and both of which are intersected by a cleavage with a constant strike different from that of each.[2] Where only one system of folding occurs, the strike of the cleavage is not necessarily parallel to that of the bedding. In such a case the cleavage is attributed to a change in the direction of the pressure.[3]

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[1] Gosselet, J., Les schistes de Fumay, pp. 68, 69, fig. 5, 1884.
[2] Loretz, H., Ueber Schieferung, pp. 69-70, 1880.
[3] Idem, pp. 83, 84.

> The cleavage planes of the slate rocks of North Wales are always parallel to the main direction of the great anticlinal axes but are not affected by the small undulations or contortions of these lines.[1]
>
> The strike of the cleavage in a district is far more constant and regular than the strike of the beds.[2]

To these facts should be added this—that in a pitching fold the cleavage, although parallel to the axis of the fold, must necessarily intersect the strikes of the sides of the fold. Phillips[3] gives a section from Sedgwick, which he calls a local exception, in which the cleavage planes, while coinciding in strike with that of the anticline that they traverse, incline on either side of it toward its axis. Rogers[4] describes a case of this fanlike cleavage in an anticline. Such a structure could be produced by secondary movement creating an anticline in horizontal beds already possessing a vertical cleavage, and in the synclinal part of the fold the fan structure would radiate downward.

Sorby[5] figures, from Ilfracombe, North Devon, a small, highly plicated bed of coarse-grained light-colored sandy slate traversing a mass of vertically cleft shaly slate. The gritty beds show a coarse and imperfect fanlike cleavage which curves slightly around the anticlines into the synclines. Here the fan structure seems to be due, in part, at least, to the deflection of the cleavage by the coarser material, and there is no need of supposing a secondary movement. The fine and more plastic material has developed a vertical cleavage which in the coarser material has become rudely fanlike.

Effect of frost on cleavage.—As all slate quarrymen know, repeated freezing and thawing is disastrous to the cleavability of roofing slates. The material must be split fresh from the quarry. In order to ascertain, if possible, the difference in microscopic structure produced by freezing and thawing this experiment was tried: A fresh and unfrozen specimen was obtained from the quarry early in the winter and was kept moist in a moderate temperature until severe weather set in. It was then broken into two equal parts, one of which was kept moist indoors, the other exposed on the sill of a north window for a week, during which the temperature went down to 10° below zero F. This part was then thawed out over a furnace register. Both frozen and unfrozen pieces were after some accidental delay sliced and examined microscopically. The whole texture of the frozen slate was found to be perceptibly closer than that of the unfrozen. The test would have been more satisfactory had the thin sections been made at once. The loss from freezing and thawing is so considerable that means to recover it have been sought, and a process has recently been patented by W. A. McLaughlin, of Delta, Pa., for restoring the fissility of slate by the use of liquid air.

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[1] Phillips, Prof., quoted in Sharpe, Daniel, Contributions to the geology of North Wales: Geol. Soc. London Quart. Jour., vol. 2, p. 309, 1846.

[2] Sharpe, Daniel, idem.

[3] Phillips, John, Report on cleavage, p. 374, 1857.

[4] Geology of Pennsylvania, vol. 2, pt. 2, p. 908, fig. 715, [illegible]

[5] Sorby, H. C., On the origin of slaty cleavage, [illegible]

Curvature of the cleavage.—As far back as 1839 De la Beche[1] called attention to the curvature of cleavage planes when approaching a bedding plane. Baur[2] in 1846 observed S-like cleavage foliation in Germany, and describes certain slates which were so much curved as to be fit for use only on the roofs of towers, but he does not explain whether this curvature was parallel or transverse to the bedding. John Phillips,[3] in his British Association report, ascribed the curvature to the differing density of the beds. Harker[4] attributes it to a gradual change in the texture of the beds. Hughes[5] explains it as due to a secondary motion. Curvature of the cleavage is not uncommon in the Lehigh and Northampton County quarries in Pennsylvania, where it is plainly not dependent on change of texture. (See p. 105.) Slates from the beds so affected are also used for roofing towers.

In some of the Pennsylvania and New Jersey quarries (p. 88) the cleavage, instead of being curved, is deflected in dip at the ribbon; and thus where ribbons abound a roofing slate of ordinary size may have several large-angled zigzags in it.

Phillips[6] gives a figure, the original authorship of which he does not mention, representing the cleavage surface of a piece of slate in which gently plicated ribbons are shown. A normal fault crosses the piece diagonally, displacing the beds. The cleavage surface also shows the "flexuous" lines of a third foliation oblique to the cleavage. Finally two small calcite veins cross the primary cleavage, the plicated bedding, the plicated secondary cleavage, and also the fault plane. The specimen thus bears traces of at least five if not six motions.

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[1] De la Beche, H. T., Report on the geology of Cornwall, Devon, and West Somerset, p. 620, fig. 31, London, 1839.

[2] Ueber die Lagerung der Dachschiefer, etc., pp. 392, 393, fig. 9, 1846. (For full titles of works cited see Bibliography, pp. 205-210.)

[3] Op. cit., p. 384, fig. 23. See also Jukes, Geol. Soc. London Quart. Jour., vol. 22, p. 359, 1866. That the angle and amount of cleavage change with the density of the rock was shown by Phillips in 1828. See also Harkness, Robert, Edinburgh New Philos. Jour., new ser., vol. 2, No. 4, 1855.

[4] On slaty cleavage, etc., 1886.

[5] Hughes, T. M., quoted in Lyell's Students' elements, 7th ed., pp. 53, 573, fig. 625, 1871.

[6] Report on the geology of Cornwall, etc., p. 372, fig. 2.

SLIP CLEAVAGE ("FALSE CLEAVAGE").

Several writers—Sedgwick,[1] Phillips,[2] De la Beche,[3] Zirkel,[4] Loretz[5]—describe a striation or an extremely fine plication that appears on the cleavage surfaces of some slates. This is the "bate" or "false cleavage" of quarrymen. Two systems of such lines or plications may occur in the same slate. These are due to a secondary and tertiary cleavage, a slip cleavage developed upon the primary slaty cleavage. They consist simply of very minute plications which usually result in microscopic slippages or faults along which the slate easily breaks. This structure may show itself where slaty cleavage alone is visible or in the bedding also. (See Pls. VII and XI, *A*.) There is a readjustment of the slaty cleavage and the bedding foliation with reference to the new pressure instead of a rearrangement of all the particles as in slaty cleavage. The presence of "false cleavage" can be detected microscopically in a piece half an inch square as certainly as from tests applied to pieces of commercial size. The specimen shown in Plate VII came from a quarry which proved a failure on account of this structure, but it was not detected until after the expenditure of much money. The slate from Arizona, described on page 60, shows two slip cleavages crossing each other, as well as both bedding and slaty cleavage.

False cleavage has received in recent years a variety of technical names, such as close-joint cleavage, strain-slip cleavage, Ausweichungs-clivage, fissility, fracture cleavage. Science is not advanced by the mere multiplication of technical terms. The term "fissility," being a synonym of Latin derivation for cleavability, which is of Anglo-Saxon origin, is likely to be misleading. "Close-joint cleavage" and "fracture cleavage" are objectionable because they may be applied to jointing. The term "slip cleavage" has brevity and definiteness in its favor, as well as priority over the two just mentioned. Slip cleavage is a common feature in schist and is particularly characteristic of the Taconic region in western Massachusetts, Vermont, and eastern New York, where it seems to be due to a con-

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[1] "While my first observations on cleavage planes were made during long bygone years in Cumberland, I had hardly noticed the phenomenon of a second cleavage plane; but on many occasions I have subsequently collected, from various parts of England, a considerable and unpublished mass of materials in illustration of this second plane. The second cleavage plane is generally inclined at a great angle to the first plane. Most beautiful examples of this double structure were seen in 1839 by Sir R. Murchison and myself in the quarries of the Ardennes, where the fine, glossy surfaces of the slates are frequently marked by the parallel striæ of second cleavage, and the economical value of the slates is sometimes much deteriorated by the second plane. By a powerful reflected sunlight I have frequently been able to trace these striæ of a second cleavage on the surface of the Bangor slates which have been brought to Cambridge." A synopsis of classification of the British Paleozoic rocks, p. xxxv, London, 1855. Also Geol. Soc. Trans., 1840, p. 655.

[2] On a group of slate rocks, p. 1, 1829.

[3] Geological observer, 2d ed., p. 588, fig. 239, 1853.

[4] Lehrbuch der Petrographie, pp. 307, 308, 1894.

[5] Ueber Transversalschieferung, pp. 263, 264, 1882. J. E. Spurr, Am. Jour. Sci., 3d ser., vol. 48, p. 159, 1894, describes slates in Minnesota with two and three cleavages and bedding.

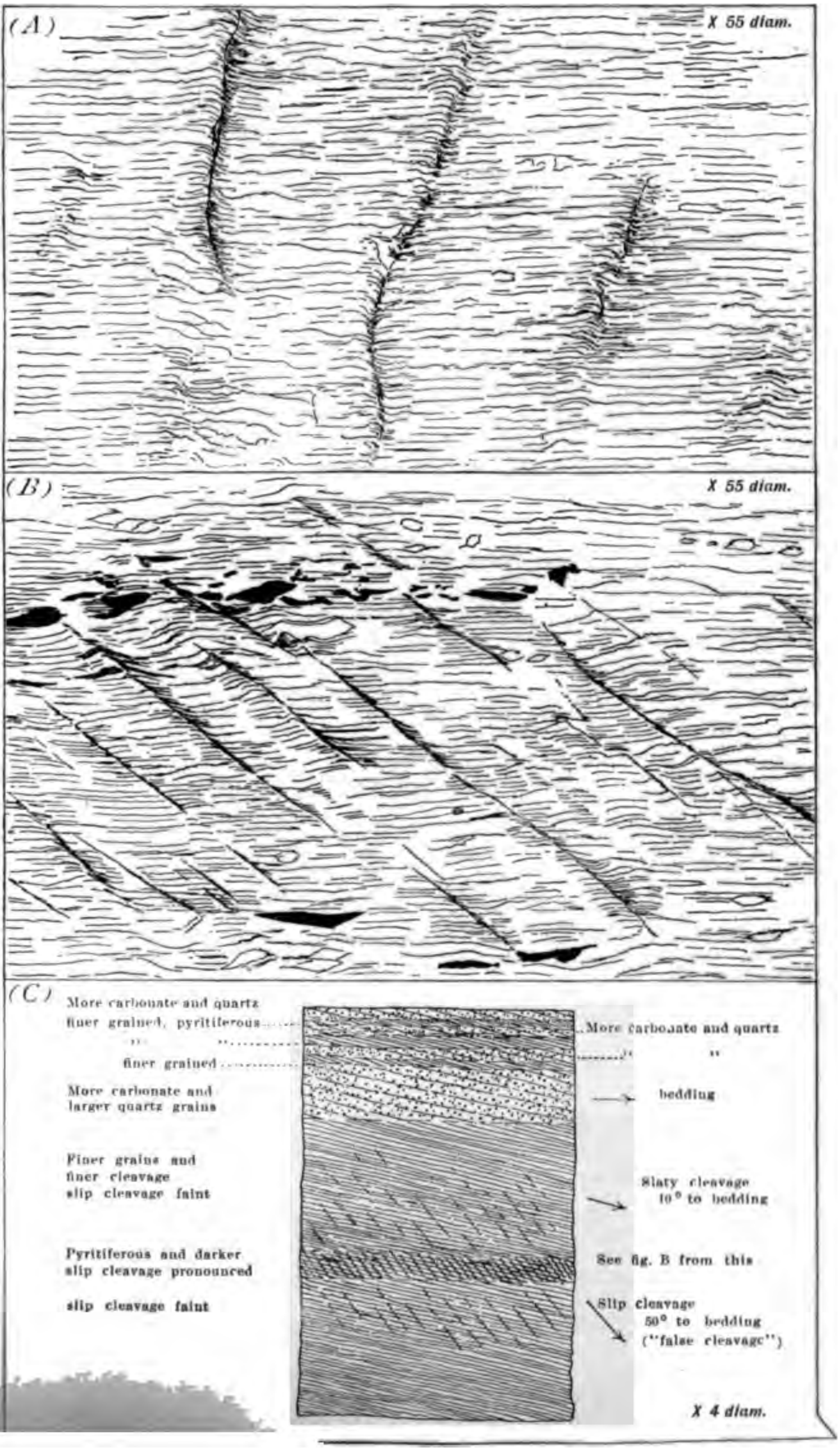
PLATE VII.

THIN SECTIONS OF ROOFING SLATE WITH SLIP CLEAVAGE ("FALSE CLEAVAGE").

A. **Microscopic view of a thin section of purple Cambrian roofing slate from an old quarry three-fourths of a mile south of Fair Haven, Vt., showing slip or "false" cleavage originating in minute wrinkles. Section transverse to both cleavages. Enlarged 55 diameters.**

B. **Microscopic view of a thin section of green Cambrian roofing slate from the** Huckleberry Hill quarry, 2 miles southeast of West Pawlet, Vt., showing slip or "false" cleavage. Section transverse to both cleavages. Enlarged 55 diameters. The black spots are pyrite. This figure represents a small part of the dark band shown in *C*.

C. Microscopic view of the same thin section, entire, showing alternation of fine and coarse beds, some of which are pyritiferous, and in only one of which is the slip cleavage pronounced. Enlarged 4 diameters.


(A)
X 55 diam.
(B)
X 55 diam.
(C)
More carbonate and quartz
finer grained, pyritiferous
" "
finer grained
More carbonate and larger quartz grains
Finer grains and finer cleavage slip cleavage faint
Pyritiferous and darker slip cleavage pronounced
slip cleavage faint
More carbonate and quartz
" "
bedding
Slaty cleavage 10° to bedding
See fig. B from this
Slip cleavage 50° to bedding ("false cleavage")
X 4 diam.

TER SLATY CLEAVAGE.

tinued if not, in some instances at least, a secondary crustal movement consequent upon the first metamorphism. H. B. Muff [1] finds in a folded Scotch slate two sets of slip cleavage, each at about 45° to the slaty cleavage. He regards all three cleavages as concomitant but not simultaneous, although a difference in the strike of the slip cleavage from that of the other structures requires a slight veering of the direction of maximum pressure toward the close of the earth stress.

Good illustrations of slip cleavage will be found in the following publications of the United States Geological Survey: Monograph XXIII (1894), figures 44, 45, 46, 53, 56; Thirteenth Annual Report, part 2 (1893), page 319, figure 25; Fourteenth Annual Report, part 2 (1894), page 537, figure 57; Sixteenth Annual Report, part 1 (1896), figures 89, 96, 97; and Bulletin 521 (1912), Plates V, *A;* VIII, *B*(b). A careful study of these microscopic drawings and photographs will show that the minute faults along which more or less slippage has occurred are the necessary result of the lateral shortening of the rock mass by plication. This plication was as much due to a lateral compression as was the major folding of the Appalachian system. Slip cleavage should therefore not be confounded with two intersecting systems of fractures (jointing on a small scale), the strike of neither of which would be at right angles to the direction of strain but diagonal to it; or to a single system of such fractures, which might be the result of stretching.[2] The same pressure which produced slip cleavage in buried masses of micaceous matter (slate and schist) may have produced fractures at the surface; but where both schist and a rigid vitreous rock like quartzite have (in contact) been subjected to the same pressure, in the Taconic region, both have usually been folded, the schist in smaller folds, the quartzite in larger ones, but slip cleavage has been confined to the schist.[3]

The faults or fractures in slip cleavage belong rather to a process of "rock flowage" than to one of "rock fracture." As Heim[4] put it: "By real cleavage is always to be understood a cleavability of the material pervading the entire mass and visible in each little fragment." A light-green slate from Bartow County, Ga., shows planes 0.05 to 0.5 inch apart, carrying secondary chlorite along which the ribbon has been displaced 0.1 to 0.9 inch by faulting. The slaty cleavage, which is at right angles to the bed, does not seem to have been affected by these faults, nor has the slate been weakened. Such faulting would not come under Heim's definition of slip cleavage.

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[1] **Peach,** B. N., Kynaston, H., and Muff, H. B., Geol. Survey Scotland Mem., Expl. Sheet 36, p. 16, fig. 3, 1909.

[2] **Pl. XIX, *A*,** in U. S. Geol. Survey Bull. 239, clearly shows close jointing, not slip cleavage.

[3] **U. S. Geol.** Survey Thirteenth Ann. Rept., pt. 2, fig. 25, 1893.

[illegible] **A., Mechanismus** der Gebirgsbildung, vol. 2, p. 59.

GRAIN.

Sharpe's explanation for slates splitting more readily along the "grain" than across it is that the mineral particles lie with their flat surfaces parallel to the cleavage and their longer axes in the direction of the cleavage dip. A fracture across the cleavage and parallel to the dip is parallel to the longer sides of the particles, whereas one parallel to the strike of the cleavage is across both longer axes and sides.[1]

Renard [2] states that the scales of chlorite lie perpendicular to the cleavage—that is, about in the direction of the grain. Jannetaz's experiments[3] in reproducing grain have already been referred to (p. 14), and his experiments showing that the direction of the grain is that of the greatest elasticity are given on page 172.

Daubrée,[4] in one of his experiments, produced a lamination in the direction of pressure and motion, which is the relation of grain to pressure. It seems, therefore, that besides the cause assigned to grain by Sharpe there is the formation of exceedingly obscure vertical divisional planes in the direction of the pressure and the crystallization of secondary minerals along these planes.[5] The variation of the strike of the grain from the direction of the cleavage dip at Rimogne (Ardennes) is from 1 to 20°. At Fumay, in the same region, that variation is 6°.[6] At Rimogne the strike of the grain bisects the acute angle formed by two sets of joints. In some of the Ardennes slates plates of hematite lie in the "grain" and indicate its direction.[7] Watrin states that as the longer axes of distorted octahedra of magnetite all lie in the direction of the grain in some of the Ardennes slates, their combined magnetism gives a polarity to the slate in the direction of the grain and enables the quarrymen to ascertain its direction by the magnetic needle. A like arrangement of lenses and distorted cubes of pyrite characterizes the slate at Northfield, Vt. (see p. 122), and of folia of biotite in the slate of Arvonia, Va. (See p. 151.)

The same feature is occasionally seen in schists. Thus scales of biotite in a schist in Beekman and Pawling, Dutchess County, N. Y., and actinolite crystals in schist in Hubbardton, Vt., have their axes in any direction, but their flat sides are transverse to bedding and cleavage.

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[1] Sharpe, Daniel, Geol. Soc. London Quart. Jour., vol. 5, p. 114, 1849.

[2] Renard, A. F., Mus. roy. hist. nat. Belgique Bull., vol. 3, p. 235, 1884.

[3] Jannetaz, E., Mémoire sur les clivages des roches (schistosité, longrain), et sur leur reproduction: Soc. géol. France Bull., 3d ser., vol. 12, p. 211, 1884.

[4] Daubrée, A., Études synthétiques, p. 422, 1879.

[5] Rosenbusch (Elemente der Gesteinslehre, fig. 73, p. 437, 1910) figures biotite scales transverse to cleavage.

[6] Renard, A. F., op. cit., vol. 3, p. 3.

[7] Daubrée, A., op. cit., p. 336.

The "grain" shows itself in a more or less obscure striation of the cleavage surface in a direction nearly parallel to the cleavage dip and locally to the dip joints. In some slates the grain is very conspicuous, as in that from Georgia sketched in figure 1.

In several of the Maine quarries the grain is abnormally nearly horizontal, but the bedding is steeply inclined. As the strike of the grain is about the same as the direction of the pressure which produced the cleavage, the logical inference seems to be that the folds at these quarries, if reconstructed, would be found to have a nearly vertical pitch, and this would have to be attributed to a secondary movement. The workmen at these quarries speak of the slate as being "on end." The slate blocks are broken along the grain to reduce them to workable proportions, and as the grain is the direction of weakness, roofing slates are always cut with their long sides parallel to the grain, but in some localities there is hardly any grain.

In making thin sections for the microscopic studies for this bulletin the writer obtained fresh specimens from the quarries with the grain direction marked on them by the foremen. Thin sections were then prepared transverse to the cleavage and parallel to the grain and also at right angles to it. Where any difference is noticeable between the two sets it consists in the presence of large flakes of chlorite with their flat sides lying in the grain direction or in the longer axes of lenses and crystals lying also in that direction, and, where the sections are very thin indeed, in many small scales of muscovite being similarly oriented. Where the matrix is very micaceous and not obscured by carbonate or other minerals, sections parallel to the grain polarize more brilliantly than those across it.

JOINTS.

Nature of joints.—Joints are simply ruptures of continuity due to various strains. Exceptionally later movements may cause slippage along joint planes and result in polishing the joint faces (slickensides). The usual character of joint planes, however, points to a sudden rupture of large masses of rock affected in all its parts by one and the same mechanical expression of energy.[1] The same stress may produce several sets of joints.

Sedgwick[2] termed the three commoner kinds of joints occurring in slate regions strike joints (joints parallel to the strike), dip joints (joints parallel to the direction of the dip), and diagonal joints (joints diagonal to strike and dip)—terms which ought to be ever kept in use. To these should be added horizontal joints (bottom or flat joints), which in some slate regions are of much economic importance.

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[1] [illegible] pp. 98-100, 1880.

[illegible] classification of the British Paleozoic rocks, p. 35, London, 1885.

Rogers[1] called attention to the parallelism of joints to dikes in Pennsylvania, a parallelism previously observed in England. This is so true in western Vermont that the proximity and course of a dike can be foretold by the prevalence of certain diagonal joints. Some joints are open and filled with vein matter; more commonly, when scarcely parted, they have their sides coated with crystals of chlorite, calcite, gypsum, pyrite, barite, anatase, etc.

Curved joints.—Exceptionally joint planes undulate like bedding planes across both bedding and cleavage. (See Pl. XVIII; also p. 157.) This may be attributed to a compression similar to that which produced the undulating sheet structure in granite. The joints shown in Plate XVIII could hardly have been produced by the flexure of a flat joint by secondary movement without faulting the syncline itself. The flat joint near the surface of the Peach Bottom slate belt, with its mass of crushed slate, is probably also of secondary origin.[2]

At Foulk Jones & Sons' quarry at Slate Hill, 2 miles northeast of Delta, Pa., a curvature in jointing has produced a conical structure 20 to 30 feet high and 15 feet in diameter at the base. In view of the peculiar curvature of fractures across the cleavage of slate resulting from the use of explosives such conical forms may also be the result of shock.

Plicated joints.—In the quarry just referred to a vertical dip joint filled with quartz three-twentieths of an inch thick is in plications from one-fourth to one-half inch wide. These plications may have been due to the zigzag course of the original fracture. Some finely plicated jointing has, however, a different history. Near the extreme north end of the slate belt of western Vermont (more exactly, one-fourth mile north of the northwest end of Hincum Pond, in Sudbury, Rutland County) there is a gray slate with a micaceous matrix in which bedding is clearly indicated by the alternation of small carbonaceous beds with noncarbonaceous beds, and also by minute beds with quartz grains as much as 0.1 millimeter in diameter alternating with beds without any quartz. All these beds are crossed at an angle of 40° by slaty cleavage, and both bedding and cleavage are crossed by joints which in places are plicated, measuring an inch from crest to crest, but they are plicated in two directions. In some parts of the rock these joints are only one-fourth inch apart and are parted from one-tenth to one-fifth inch, the openings being filled with banded veins of quartz and fibrous calcite. The solution of these veins at the surface has left a series of plicated gaping joints crossing both bedding foliation and slaty cleavage. Under the microscope these joint veins are seen to consist on either side of a border of vein quartz, followed by a band of calcite fibers, then a band of quartz, and a central band of gently curving calcite fibers with a central parting containing a little quartz at intervals. The slate between these joints also shows a slip cleavage crossing bedding and slaty cleavage in the general direction of the joints but not plicated. The history of this slate thus appears to be: (1) The folding of a mass of marine sediments of alternating composition and the formation of slaty cleavage at an angle of 40° to the folded beds; (2) compression along the strike resulting in slip cleavage; (3) the elongation of the mass along the strike, producing open joints; (4) compression, both in the direction of the dip of the slaty cleavage and in a direction at right angles to that, thus plicating the joints in a twofold way; (5) the infiltration of SiO_2 and $CaCO_3$ in alternation into the open joints, resulting in banded veins; (6) the solution of the $CaCO_3$ by carbonic and organic acids and the crumbling away of the SiO_2 in consequence of exposure by erosion. Such a slate shows what complex structures successive crustal movements may produce in ordinary sediments as well as how fatal such movements may be to the commercial value of slate. These joints were probably first formed by elongation and thus are different from ordinary joints.

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[1] Rogers, H. D., Geology of Pennsylvania, vol. 2, pt. 2, p. 912, fig. 718 (joints in red shale parallel to dike), fig. 719 (joints in argillaceous sandstone), 1858.

[2] See, on curved joint planes in the Peach Bottom district, Mathews, E. B., Maryland Geol. Survey, vol. 2, p. 223, Pl. XXII, fig. 1, 1898.

FAULTS.

Faults of no great magnitude are common in slate regions. The fault plane is frequently a cleavage or a joint plane. From the shear involved in slaty cleavage reversed faults are more common in slate than normal faults.[1] Minor faults in slates from the western Vermont region are shown in Plate IV, *C*, *D*. One of these is a normal fault, the part overlying the fault plane having slid down; the other is a reverse fault, the similar part having been forced up. A microscopic section across the reverse fault shows the sharp bending of the beds at the fault plane and the deposition of a thickness of one-sixteenth of an inch of vein matter in bands along that plane. This matter consists of chlorite, calcite, and quartz.

Some of the slate slabs in the sidewalks of the villages of the Vermont-New York slate belt are finely faulted. The slate of Bolivar, Ga., is similarly faulted, but diagonally to the grain, and possibly the faulting occurred prior to the setting up of slaty cleavage. Faulting may occur both along the cleavage and along the grain—that is, in two directions at right angles to each other.[2]

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[1] See Herbert, E. J., Reversed faults in bedded slates: Geol. Mag., new ser., dec. 2, vol. 4, p. 441, 1877.

[2] Such faulting occurs in the Hudson slates of Rensselaer County, N. Y. (U. S. Geol. Survey Thirteenth [illegible], pt. 2, Pl. CI, p. 280, fig. 26, 1893). See also, in this connection, Teall, J. J. H., A faulted slate [illegible] dec. 2, vol. 1, Pl. I, London, 1884.

The dropping of a block of some superjacent valueless strata into a mass of commercial slate between two fault planes is a possibility that should not be overlooked in slate quarrying.

SHEAR ZONES.

The terms "shear zones," "zones of shearing," "Knickungsebenen," and "Querknicke" apply to one and the same feature. Rosenbusch,[1] Brögger,[2] Reusch,[3] and Turner[4] describe shear zones in Norway, Saxony, Alsatia, and California. Their occurrence in the slate belt of eastern New York and western Vermont is fully described below. The writers cited explain this feature as an angular plication, or a series of such plications, due to shearing pressure on somewhat rigid material. In places the pressure was great enough to produce a slight faulting on either side of the deflected portion or zone. Very rarely a cleavage foliation is produced within the zones. Turner's term, abbreviated to "shear zone," affords a convenient designation, with the understanding, however, that in this sense it applies only to sedimentary rocks.

The term "hogback" is used by coal miners to describe a sharp rise in the floor of a coal seam. The propriety of its application in slate quarries is not so obvious. It is used there to designate peculiar bends or fractures, which consist of two angular bends in opposite directions and near each other, traversing a mass of slate. These flexures may merge into fractures, and the slate between the two planes of fracture is broken into small fragments. The two bends or fractures may be from one-sixteenth of an inch to 4 feet apart. At one of the old quarries at Middle Granville, N. Y., a slate surface shows within a space of 4 inches four shear zones from one-sixteenth to one-fourth inch in width. Another has six in a space of 6 inches. At one of the quarries at Arvonia, Va., a mass 5 feet thick is traversed by numerous shear zones. As these zones generally traverse the cleavage diagonally, the blocks of slate adjacent to them come out in triangular form and thus occasion much waste. The strike of some of the shear zones in western Vermont is parallel to that of several of the dikes, and both may have been formed under the same stress. Figures *E*, *G*, and *I*, Plate XXIII, and figures *L*, *U*, and *V*, Plate XXIV, show the relations of shear zones at several quarries. Plate VIII, *A*, shows the microscopic structure of the "hogback" of Plate XXIV, *V*. The section was made where the bends had not as yet developed into complete fractures. The entire width of the shear zone is nine-tenths of an inch. Between the two sides is a system of cracks crossing the cleavage at an angle of 15°; another system crosses the cleavage at 25° and extends beyond one side. This may be the original bedding. Both of these systems of cracks are filled with secondary calcite. Another set, likewise filled with calcite, crosses the cleavage here and there about at right angles, but in zigzag. (See figs. *B*, *C*, *D*, Pl. VIII.) These cracks, farther on in the quarry, become continuous fractures. The secondary fractures within the zone probably result eventually in breaking up the slate, as it occurs usually in fragments within a fully developed shear zone. The observations at this quarry were: Strike of bed N. ±, dip 30° E.; strike of cleavage N. ±, dip 42°–45° E.; strike of shear zone N. 35°–40° E., dip 65° NW. In this quarry the strike of the shear zone corresponds to that of the diagonal joints of the region and of a number of the dikes. Figures *E* to *L*, Plate VIII, illustrate the development of a shear zone still further. In figure *L* the diagonal fractures are filled with quartz, and a slip cleavage also occurs. Other observations of shear zones are given in the quarry tables, pages 137, 138.

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[1] Rosenbusch, H., Die Steiger Schiefer, p. 95, 1877.

[2] Brögger, W. C., Die silurischen Etagen 2 u. 3 im Kristiania Gebiet auf Eker, p. 216, fig. 31, Kristiania, 1882.

[3] Reusch, H., Die fossilienführenden krystallinischen Schie[illegible]rn in Norwegen: German translation by R. Baldauf, pp. 52, 53, fig. 35; and p. 38, fig. 23, Leip[illegible]

[4] Turner, H. W., Further contributions to the geology of [illegible]ada: U. S. Geol. Survey Seventeenth Ann. Rept., pt. 1, p. 66[illegible] 1896.

CLEAVAGE BANDS.

While characteristic of slate regions, cleavage bands do not occur or have not yet been reported in commercial slate. They would be quite as objectionable as shear zones.

Plate XI, *B*, is made from a photograph taken by the writer at a locality in Rupert, Vt., found by L. M. Prindle. Cleavage banding is of common occurrence in the Vermont and New York slate belt and in the schist mass east of it, although not always as well shown as at this point. It resembles the shear-zone structure just described but presents further stages. The rock shown in Plate XI, *B*, is divided into alternate bands of hard, uncleft quartzose shale and bands of very finely cleft shale. The bedding zigzags across both bands. The material of both bands was originally identical. The present differences are the result of a difference in the amount of motion—that is, of slip cleavage—along alternating strips of rock and of the consequent difference in resistance to erosion. There is also a difference in color, some infiltration of limonite having taken place along the more highly cleft bands.

A similar structure in purple slate is shown in figure 3 (p. 47), but here the bands themselves have slipped.[1] Small beds of green slate indicate the course of the stratification and show the amount of slippage suffered by the bands.

Along Poultney River about a mile east of East Poultney certain hard bright-green and purple slates near the schist mass show the

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[1] See also U. S. Geol. Survey Sixteenth Ann. Rept., pt. 1, pp. 561–564, figs. 88–91, 1896.

PLATE VIII.

SHEAR ZONES.

A. Diagram of thin section of "sea-green" Cambrian slate from Williams & Edwards's quarry in Wells, Vt. Enlarged 2 diameters. Section across the cleavage and an incipient shear zone, showing the two bends in opposite directions and developed in but two places into fractures. Secondary fractures at 15° to cleavage cross the zone. A calcareous strip, possibly a trace of bedding, crosses the cleavage at 45°. All the fractures filled with calcite.

B, *C*, *D*. Microscopic drawings from thin section shown in *A*, enlarged 40 diameters, showing in reversed position the outlines of several of the vertical and diagonal fractures within and at edge of zone.

E. Diagram from specimen of shear zone, from E. E. Lloyd's sea-green slate quarry, Poultney, Vt.

F. Slate from within a fully developed shear zone, showing outline of fracture. Same location as *E*.

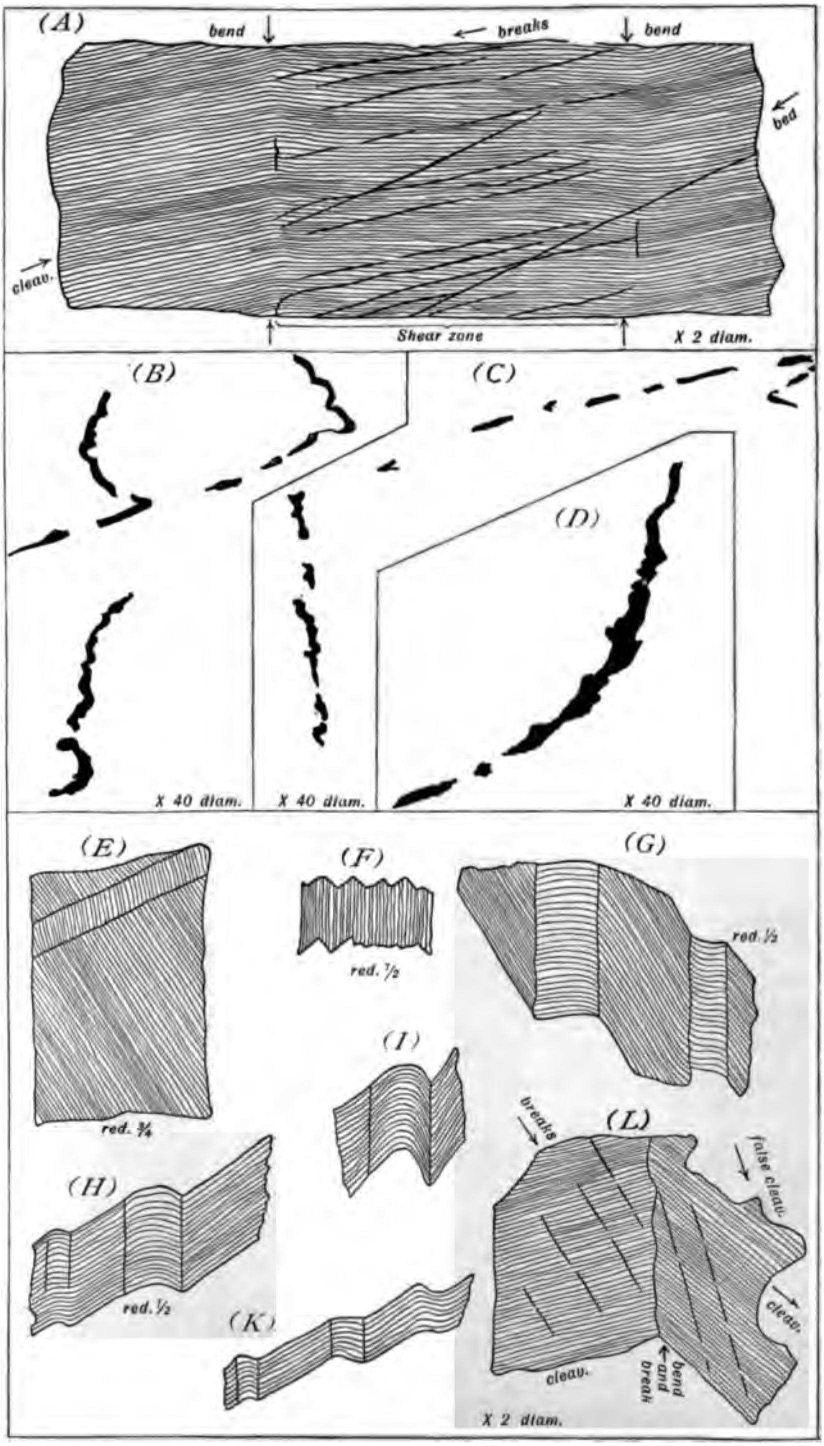
G. Slate showing two shear zones. Same location as *E*.

H. Diagram from specimen of Cambrian slate from Eddy Hill, Fair Haven, Vt., showing development of shear zones. Secondary quartz occurs along the fractures. One-half natural size.

I. Shear zone in Ordovician schist 1½ miles east of Rupert, Vt.

K. Diagram from specimen from top of the Pattern, in Pawlet, Vt.

L. Diagram from thin section of Cambrian slate from Eddy Hill, Fair Haven, Vt., enlarged 2 diameters, showing one of the main fractures of a shear zone with diagonal fractures which are filled with quartz, and beside it slip cleavage.


(A)
bend
breaks
bend
bed
cleav.
Shear zone
X 2 diam.
(B)
(C)
(D)
X 40 diam.
X 40 diam.
X 40 diam.
(E)
red. ¾
(F)
red. ½
(G)
red. ½
(I)
(H)
red. ½
(K)
(L)
breaks
false cleav.
cleav.
bend and break
cleav.
X 2 diam.

SHEAR ZONES.

cleavage banding well. In breaking up such a rock the denser uncleft parts come out in slablike blocks, the larger surfaces of which lie transverse to the bedding.

Becker[1] explains this structure by the alternate interference and coincidence of waves of vibration produced by shock. Where the waves of vibration coming from opposite directions coincide, cleavage fractures—that is, planes of slip cleavage—will be numerous.

Van Hise[2] regards such structures simply as the result of the concentration or sparseness of slip cleavage.

In the ledge figured in Plate XI, *B*, there are between 360 and 530 such planes to the inch in the cleft bands. The hard bands in the same ledge show as many fractures, but they are discontinuous or merely incipient. Both hard and soft bands consist of stratified shale made up of quartz fragments, muscovite and chlorite scales, etc., but in the soft bands the pressure has in places brought about sufficient alignment of the muscovite to produce aggregate polarization, not in the direction of the slip cleavage but in that of the bedding. There has also been a formation of sericite along the slip-cleavage planes, and thus the rock is becoming a schist.

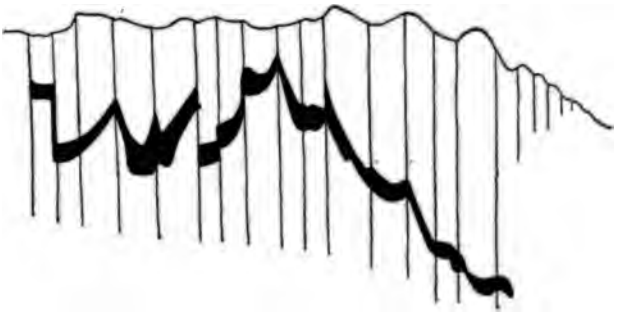


FIGURE 3.—Cleavage banding showing slippage of bands, at brook in Gorham, Poultney, Vt.

In a piece of sericite schist from the mass east of Rupert the rock consists of alternating strips with and without slip cleavage, those without being wider. The slip-cleavage planes meander about and run into one another, though having a general parallelism. The plication is much more intense and irregular in the cleft strips and also appears to be more sericitic there.

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[1] Finite homogeneous strain, flow, and rupture of rocks: Geol. Soc. America Bull., vol. 4, Jan., 1895. On page 16 he says: "Thus there seems sufficient reason to believe that a pressure very rapidly applied, producing primary ruptures attended by schock, will be immediately followed by secondary ruptures in the same direction as the others at intervals dependent upon the wave length of the impulse. In much the same way a high explosive shatters a rock far more than black powder. A phenomenon of which no explanation has been offered in this paper is that of thick slates and of those flags which are to be considered as very thick slates. These, though cleavable in a certain thinness are not capable of further splitting. Such rocks indicate a flow which is not uniformly distributed through the mass but on the contrary passes through maxima at intervals corresponding to the thickness of a slate or flag. It is possible that at the inception of strain such masses were in a state of tremor so intense that the interference of waves determined surfaces along which flow began. These surfaces would be weakened by the flow, and further strain would be distributed among them rather than over the intervening solid sheets. Effects of a similar kind are produced on a pile of sheets of paper, such as 'library slips,' resting on an inclined cloth-covered table which is jarred by rapid blows."

[2] Principles of North American pre-Cambrian geology: U. S. Geol. Survey Sixteenth Ann. Rept., pt. 1, pp. 662-664, 1896.

In all these cases the fractures are the result of the plications.

It seems probable that the shear zones represent but a variation of the process involved in the cleavage bands. The force bent and crushed the slate in the bands instead of producing very numerous planes of slip cleavage within them.

VEINS.

Quartz veins, or "flints," as the quarrymen call them, are a striking feature of slate beds and a cause of perplexity in quarrying. They appear at the most unexpected points, ramify very irregularly, and disappear as abruptly. Plate V, *A*, from a photograph taken at the old quarries at Jamesville, N. Y., shows a good type of such veins of segregation. Some of these veins show a rough parallelism. They may occur partly in the bedding and partly in the cleavage or may cross both bedding and cleavage, their general dip being roughly at right angles to that of the cleavage and their strike probably not very different from that of cleavage and bedding. Such veins may be several hundred feet long and several feet thick or may form lenses several feet in length. At Benson, Vt., and Ijamsville, Md., small joint veins of fibrous calcite form series of gashes "en échelon." The fibers or prisms lie transverse to the course of the vein. Daubrée[1] regards such veins as due to stretching. It is evident that the material of the veins described, of whatever sort, must have come from the adjacent slate itself, and also that it was deposited in solution.

In the cases adduced there is some relation between the foliations of the slate and the course of the veins, but some veins appear to be quite lawless, crossing in every direction, anastomosing, intersecting one another, and in places inclosing fragments of the adjacent slate and constituting the cement of a brecciated mass. That the veins are the result of various secondary stresses, producing openings of more or less irregularity, is manifest. Where the stress ceased to operate the vein tapers out; where the stresses were complex the veins are complex also.

The material which filled the openings thus made is chiefly quartz, commonly "milky" in color and in many places finely crystallized in small cavities. With the quartz are often associated chlorite, biotite, calcite, and possibly dolomite. The chlorite locally occurs in hexagonal scales, in vermicular aggregations, or in tortuous columns. Some of the smaller veins are banded, presenting alternations of quartz and fibrous calcite, or of quartz and rhombs of calcite, like those in plicated joints described on page 42. Here and there the quartz contains cavities measuring from 0.002 to 0.005 millimeter in diameter, filled with fluid, each containing a moving vacuole, as in the quartz of granites.[1] Galenite in small particles was found in veins in the quarries at Jamesville, N. Y.

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[1] Daubrée, A., Géologie expérimentale, p. 144, fig. 166, 1879.

NODULES.

In some of the western Vermont quarries very hard lenticular nodules, a few inches in diameter, occur along the bedding planes. They consist of a quartzite nucleus containing much calcite and large scales of muscovite surrounded by slaty layers carrying calcite, quartz, and muscovite scales. Pyrite is disseminated throughout both nucleus and outer zone. Such nodules are evidently of sedimentary origin.

Müller[2] describes concretions of pyrite and quartz in the slate quarries of Thüringen and observes that the slate in their vicinity is of superior quality, containing less pyrite than it does at a distance from the nodules. The explanation is that all the pyrite has congregated in the large nodules instead of being more widely disseminated in small crystals. The nodules are thus of economic advantage.

DIKES.

Volcanic dikes are not uncommon in slate deposits. Aside from the very exceptional one described by Mr. Eckel on page 68, dikes are almost as detrimental as veins. They are usually more regular than veins of segregation, and, as stated under "Joints," their proximity is likely to be indicated by an abundance of joints parallel to them. For several feet on each side of the dike these joints become very close and are in places crossed by an equally numerous set of horizontal joints, thus breaking up the slate into small blocks. At Arvonia, Va., the quality of the slate a little beyond the dike is better than it is farther away, so that a dike traversing a slate deposit is not necessarily without economic value.

GEOLOGIC RELATIONS OF SLATE.

In view of the origin and structure of the marine sedimentary slates it is evident that such slate deposits are to be looked for along the borders of or in proximity to granitic land masses where the dominant pressure has come mainly from one direction and where it has not been sufficiently intense to result in extreme metamorphism. The slate belt of Maine lies not far south of a granitic area. Two of the slate belts of Vermont are but a few miles west of the Green Mountain granitic axis and two others east of it. In eastern Pennsylvania, West Virginia, and Maryland the slates lie not far northwest of a granitic area, and the slate of Virginia is not many miles southeast of one.

From the facts brought out in considering the structure of slate it is also evident that slate belts generally bear evidence of more than one crustal movement. Along the entire Appalachian province, where at least two major mountain-making movements occurred—the Ordovician and the Carboniferous—and where the slates are mostly of Cambrian or Ordovician age, they must needs show the effect of at least one disturbance of the slaty cleavage.

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[1] Dale, T. N., The chief commercial granites of Massachusetts, New Hampshire, and Rhode Island: U. S. Geol. Survey Bull. 354, pp. 42-47, 1908.

[2] Müller, F. E., Die normalen Schiefer des Hennbergs: Neues Jahrb., 1882, vol. 2, p. 218.

Where, as in western Vermont and eastern New York, slates of two geologic periods occur in proximity, and where one is even superposed on another, the question of their mutual relations becomes of economic and scientific importance.[1] There was here at the close of Lower Cambrian time a crustal movement which resulted in the cleavage of the Lower Cambrian sediments and their emergence They were afterward in places submerged and received Ordovician deposits, which, at the close of Ordovician time, were folded and also received a slaty cleavage. Moreover, the folds of both periods are overturned.

CHEMISTRY OF SLATE.

CHEMICAL COMPOSITION.

Comparatively few complete chemical analyses of roofing slates have found their way into scientific literature. Several of the rare elements are usually omitted. FeO and Fe_2O_3 are not distinguished, nor CaO and CO_2, so that several of the percentages are more or less misleading. Fourteen selected analyses, all but one from European sources, are here given for reference.

Selected analyses of roofing slates.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Silica (SiO_2)	58.30	61.57	65.63	61.43	67.56	59.35	55.880	55.06	60.68	60.17	56.71	56.92	57.23	63.06
Titanium dioxide (TiO_2)	.23	1.31	.94	.73	......	1.00	1.270	......	.59	1.15	.70	.90	.89	.73
Alumina (Al_2O_3)	21.89	19.22	20.20	19.10	12.23	13.56	21.849	22.55	21.20	18.89	14.43	16.41	20.43	18.03
Ferric oxide (Fe_2O_3)	7.05	6.63	2.72	4.81	2.87	1.10	......	1.97	5.68	6.17	1.98	.53	1.33	2.24
Ferrous oxide (FeO)	2.57	1.20	.85	3.12	6.99	4.75	9.033	5.96	.46	.95	3.65	3.52	5.64	4.07
Lime (CaO)	.39	.22	.19	.31	.27	5.20	.155	1.30	1.71	1.75	3.83	2.94	1.54	.81
Baryta (BaO)	......	......	......	......	......	......	......	......	......	.04	.04	.03	.02	......
Magnesia (MgO)	1.09	2.00	1.54	2.29	3.03	3.60	1.495	2.92	.88	1.85	3.47	3.14	2.49	2.21
Potassa (K_2O)	2.45	3.63	3.81	3.24	1.76	1.77	3.640	3.82	3.64	2.76	2.61	3.27	2.39	3.07
Soda (Na_2O)	1.18	.93	.71	.83	1.28	1.48	.460	2.17	2.09	1.39	2.59	1.47	3.97	1.51
Carbon dioxide (CO_2)	......	......	......	......	......	4.45	......	......	......	1.04	3.71	2.68	......	None
Carbon (C)	......	......	......	......	3.11	......	1.794	......	.07	......	.77	1.54	Trace	......
Manganous oxide (MnO)	......	......	......	......	0.10	0.31	0.586	......	0.16	0.20	0.06	0.16	0.05	0.30
Phosphoric oxide (P_2O_5)	......	......	......	......			......			.11	.05	.09	.54	.06
Sulphuric oxide (SO_3)	......	......	......	......			.022	......		......	.12	.10	.03	.09
Water (H_2O)	4.61	3.25	3.17	3.52	1.00	3.41	3.385	4.35	2.88	[a]3.70	[a]2.74	[a]2.21	3.94	[a]3.62
Pyrite (FeS_2)	......	......	......	......	......	......	.051	......	......	......	2.64	3.97	......	......
Cobaltous oxide (CoO)	......	......	......	......	......	......	Trace	......	......	......	......	......	......	......
	99.76	99.96	99.76	99.38	100.20	99.98	99.801	100.10	100.04	100.17	100.10	99.88	100.09	99.80
Specific gravity[b]	2.81	......	......	......	......	......	[c]2.89	2.78	......	......	......	......	......	2.83

[a] Combined water.

[b] The specific gravity of the Festiniog black slates of Wales was determined as 2.751 at the physical laboratory of Williams College in 1899. Since the publication of Dr. Hillebrand's note on the slates of New York and Vermont, Reade and Holland find as a mean of 13 Welsh slates Cr_2O_3, 0.003; V_2O_5, 0.032; ZrO_2, 0.022. See Liverpool Geol. Soc. Proc., 1900–1901, p. 101 and table.

[c] Specific gravity from Merriman.

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[1] See U. S. Geol. Survey Bull. 242, 1905.

1. Gray roofing slate, best quality, Delabole, Camelford, Cornwall; two analyses by J. A. Phillips, London, Edinburgh, and Dublin Philos. Mag., 4th ser., No. 27, pp. 95-96, Feb., 1871.
2. Purple roofing slate, Fumay, Ardennes, northwest France; by A. Renard, Recherches sur la composition et la structure des phyllades ardennais; Mus. roy. hist. nat. Belgique Bull., vol. 1, p. 239, 1882.
3. Green roofing slate beds from purple, Fumay, Ardennes, as above.
4. Blue-gray roofing slate, La Richolle quarry, Rimogne, Ardennes, northwest France; by Klement; Renard, A. F., op. cit., p. 233.
5. Roofing slate (probably black, Devonian), Westphalia; by H. von Dechen; Roth, J., Allgemeine und chemische Geologie, vol. 2, pp. 586, 587, 1884. (No. 107.)
6. Roofing slate (color not given, Devonian). Frankenberg, near Goslar, in Prussia; by A. von Groddeck; Preuss. geol. Landesanstalt Jahrb. 1885-86; quoted by Roth, J., op. cit., pp. 586, 587.
7. Black roofing slates (Peach Bottom) from J. Humphreys Co.'s quarry half a mile east of Delta, York County, Pa.; by Andrew S. McCreath, Second Geol. Survey Pennsylvania Rept. Prog., vol. CCC, pp. 269, 270, 1880.
8. Bluish roofing slate of Carboniferous age, Mohradorf, near Wigstadl, Austrian Silesia; by Nikolic, Min. pet. Mitt., 1871, p. 207; quoted by Roth, J., op. cit., pp. 588-589.
9. Blue slate, Glyn quarries, Llanberis, Wales; analysis made at Museum of Practical Geology, London, for George Maw, Geol. Mag., vol. 5, p. 123, London, 1868.
10. Reddish roofing slate (best), Alexandra quarry, Moel Tryfaen, North Wales; by Reade and Holland, Liverpool Geol. Soc. Proc. 1899-1900. (No. 1.)
11. Very dark banded roofing slate, Llansantfraid, Glyn Ceiriog, near Llangollen, North Wales; by Reade and Holland, op. cit. (No. 2.)
12. Very dark roofing slate, Moel Ferna. North Wales; by Reade and Holland, op. cit. (No. 3.)
13. Green roofing slate from quarry between Camlyn and Cemmaes, Anglesey; by Reade and Holland, op. cit. (No. 4.)
14. Green roofing slate, Velenhelli, Wales; by Reade and Holland, op. cit. (No. 6.)

The 15 complete analyses of New York, Vermont, and Pennsylvania roofing slates made by the chemists of the United States Geological Survey and given under the descriptions of those slates are summarized in the following table. Wherever several analyses were made of one kind of slate the average is given. The rarer elements and water below 110° C. have here been thrown together.

Summarized analyses of roofing slates from New York, Vermont, and Pennsylvania.

	New York.		Vermont.					Lehigh County Pa.	General average.
	Bright green. (1)[a]	Red. (4)	Sea-green. (3)	Unfading green. (2)	Variegated (Eureka). (1)	Purple. (2)	Black. (1)	Black. (1)	
Silica (SiO_2)	67.89	63.89	63.33	59.37	60.24	61.29	59.70	56.38	61.51
Titanium dioxide (TiO_2)	.49	.52	.73	1.00	.92	.77	.79	.78	.75
Alumina (Al_2O_3)	11.03	11.80	14.86	18.51	18.46	16.24	16.98	15.27	15.39
Ferric oxide (Fe_2O_3)	1.47	4.56	1.12	1.18	2.56	4.63	.52	[b] 1.67	2.21
Ferrous oxide (FeO)	3.81	1.33	4.93	6.69	5.18	2.62	4.88	[b] 3.23	4.08
Lime (CaO)	1.43	2.25	1.20	.49	.33	.60	1.27	4.23	1.47
Magnesia (MgO)	4.57	4.57	2.98	2.36	2.33	2.99	3.23	2.84	3.23
Potassa (K_2O)	2.82	3.95	4.06	3.78	4.09	5.27	3.77	3.51	3.90
Soda (Na_2O)	.77	.50	1.22	1.71	1.57	1.38	1.35	1.30	1.22
Carbon dioxide (CO_2)	1.89	3.15	1.41	.30	.08	.54	1.40	3.67	1.55
Pyrite (FeS_2)	.04	.02	.11	.14	.16	.04	1.18	1.72	.42
Water above 110° C. (H_2O)	3.21	2.82	3.37	4.01	3.81	3.16	3.82	4.09	3.53
Carbon (C)	......	......	Trace.	......	......	......	.46	.59	......
Sundry and water below 110° C	.66	.77	.69	.51	.39	.56	.70	1.11	.67
	100.08	100.13	100.01	100.05	100.12	100.09	100.05	100.39	......
Specific gravity [b]	2.717	2.796	2.776	2.795	2.805	2.806	2.774	2.783	2.783

[a] Figures in parentheses indicate the number of analyses averaged.

[b] Approximate.

If analysis K^2 of red slate on page 92 is included with the four others, the Fe_2O_3 in the red slates would range from 3.48 to 7.10 per cent and would average 5.08. Comparing, then, the amount of Fe_2O_3 in the colored slates, we shall find that it steadily increases from the variegated to the purple and to the red, as the microscopic sections show.

On the other hand, there is a decrease of FeO in passing from the unfading green to the variegated, sea-green, bright green, purple, and red. This decrease corresponds to and is probably consequent on the decrease of chlorite, a hydrous silicate of MgO and FeO.

There is more lime (CaO) and carbon dioxide (CO_2) in the Lehigh slate than in any of the others. There is less CaO and CO_2 in the unfading green and in the variegated analyzed than in any of the other slates.

There is less pyrite (FeS_2) in the red and most in the black.

Dr. Hillebrand's discussion of the analyses of slates from New York and Vermont and of the causes of the discoloration of the sea-green slate is given on pages 55–59. While his investigation was undertaken primarily to determine the cause of discoloration in one kind of slate, microscopic analyses show that discoloration in the black slates of Pennsylvania is also greatest where carbonate is most abundant. It is safe to assume that ferrous carbonate plays an important part in the discoloration, not only in these slates but in all slates. The red slates of New York contain much carbonate but do not discolor, the carbonate probably not being ferrous.

These 29 analyses are sufficient to give within certain limits the essential chemical composition of commercial slate of aqueous sedimentary origin.

Range of composition of slate.

Silica	55–67	Soda	0. 50–3. 97
Alumina	11–23	Magnesia	0. 88–4. 57
Ferric oxide	0. 52–7	Lime	0. 33–5. 20
Ferrous oxide	0. 46–9	Water above 110° C	2. 82–4. 09
Potash	1. 76–5. 27		

For comparison a composite analysis of 51 American Paleozoic shales made by H. N. Stokes, of the United States Geological Survey,[1] is added, the unessential elements being omitted.

Composite analysis of 51 Paleozoic shales.

Silica	60. 15	Soda	1. 01
Alumina	16. 45	Magnesia	2. 32
Ferric oxide	4. 04	Lime	1. 41
Ferrous oxide	2. 90	Water above 110° C	3. 82
Potash	3. 60		

As these figures come between the extremes of the slate analyses, and as the analyses of numerous clays and some schists do also,[2] it is evident that a chemical analysis of a slate is not sufficiently characteristic to prove that it is not that of a shale, a clay, or a schist. Indeed, but for the low maxima for soda (2.17, 2.59, and 3.97 per cent) in three out of the 29 analyses, and the high minima for combined water, many granites, syenites, porphyries, diorites, and basalts could pass chemically as roofing slate. It follows from the foregoing discussion that while considerable scientific interest attaches to the chemistry of slate there is little correlation between its chemical composition and its physical properties. These depend primarily on its texture and secondarily on its mineral composition, and both of these are best determined by microscopic examination.

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[1] U. S. Geol. Survey Bull. 168, p. 17 (B), 1900.

[2] For clays see Ries, Heinrich, Technology of the clay industry: U. S. Geol. Survey Sixteenth Ann. Rept., pt. 4, pp. 523–575, 1895; also Prof. Paper 11, 1903. For schist, see Clarke, F. W., and Hillebrand, Analyses of rocks, etc.: U. S. Geol. Survey Bull. 148, p. 221 (L) and p. 99 (K), 1897.

That there should be chemical similarity between slate, shale, and clay results primarily from the fact that the slate here considered is simply metamorphosed shale and that shale is compressed clay. Whatever mineralogic changes metamorphism brought about, the same elements persisted. In some mica slates the grains of quartz, feldspar, zircon, and other minerals are the identical ones of the original clay sediment. The economic bearing of the chemical analyses of slates will be brought out under "Methods of testing slate," in the section on economic geology (p. 180).

CHEMICAL CHANGES IN WEATHERING.

The changes in substance and color which slates undergo in weathering are striking. The black slate of the Peach Bottom district (Pennsylvania and Maryland) and of Buckingham County, Va., passes into a bright reddish-brown clay; the black slate of Lehigh and Northampton counties, Pa., passes into a yellowish ocherous clay and finally into a white clay; and the black slate of Rockmart, Ga., passes into a bright yellow ocherous clay. These alterations will be referred to in the descriptions of each district. These changes in weathering should not, however, be confounded with the relatively slight discoloration which slates on the roof undergo during a fraction of a century or even several centuries. The former changes required tens of centuries.

G. P. Merrill[1] has investigated the weathering of the Peach Bottom slate and has shown that in the passage from the black slate to the red clay the following losses occur: 57.57 per cent of the SiO_2, 8.78 per cent of the iron oxides, all the lime, 28.16 per cent of the MgO, 77.95 per cent of the K_2O, and 99.64 per cent of the Na_2O. All the Al_2O_3 remains, as well as the water. A piece of Peach Bottom slate in the first stages of weathering, examined microscopically by the writer, shows the magnetite crystals and lenses passing into hematite and the andalusite crystals becoming limonitic from the oxidation of its ferruginous inclusions.

In connection with some chemical analyses of slates from Lehigh County, Pa., Dr. Hillebrand made some partial analyses of a piece of black slate from a ledge near the Berks and Lehigh county line, 1¼ miles north-northwest of Rothrocksville, on the road to Hynemansville, in which the stages of weathering were finely shown.

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[1] Rocks, rock weathering, and soils, New York, 1897.

Analysis A represents the black but slightly altered part of the slate; B the greatly altered white part of the same specimen. The alteration has proceeded first along the bedding planes, which there undulate in a vertical direction, and from these along the cleavage, which dips only about 12°. These analyses, when compared with analysis A of fresh black slate from the Slatington quarries (see p. 108), 14 miles farther north-northeast, show a probable loss of 4 per cent of CaO during a still earlier stage of weathering.

Analyses of weathered slates from Pennsylvania.

	A	B
Silica (SiO_2)	65.56	68.81
Alumina (Al_2O_3) Phosphoric oxide (P_2O_5)	17.06	16.44
Ferric oxide (Fe_2O_3) Ferrous oxide (FeO)	4.19	3.14
Magnesia (MgO)	1.31	1.00
Lime (CaO)	.20	.20
Soda (Na_2O)	.26	.27
Potassa (K_2O)	3.81	4.32
Water (H_2O)[a]	7.09	5.33
Titanium dioxide (TiO_2)	.68	.77
Carbon dioxide (CO_2)	None.	None.
Sulphur (S)	.02–.04 FeS_2	....
	100.18	100.28

[a] Including carbonaceous matter.

A thin section of another specimen from the same ledge, made across both dark and light parts, shows under the microscope:

1. Absence of carbonate in both parts, the carbonate having been previously dissolved out.
2. Many spherules of pyrite in the dark part, some of which, altered to limonite, still remain in the white part.
3. Quartz grains, equally numerous in both parts.
4. Muscovite (sericite) much more conspicuous in the light than in the dark part.

To the above data should be added two analyses, by Dr. Hillebrand, of white "shale clays," which are regarded as the residual product of the weathering of the black slate.

Analyses of shale clays from Lehigh County, Pa.

	C	D
Silica (SiO_2)	64.50	75.77
Alumina (Al_2O_3)	[a] 21.67	[b] 15.30
Ferric and ferrous oxide (Fe_2O_3 and FeO)	1.83	....
Magnesia (MgO)	1.09	.81
Lime (CaO)	.18	.20
Soda (Na_2O)	.20	Trace.
Potassa (K_2O)	4.26	2.85
Water above and below 110° C. (H_2O)	[c] 5.65	4.69
Titanium dioxide (TiO_2)	.85	.36
	100.23	99.98

[a] Including P_2O_5. [b] With trace of Fe_2O_3 and (perhaps) P_2O_5. [c] Ignition loss.

C. White "shale clay" quarried for fire clay half a mile south of Fogelsville, Upper Macungie, Lehigh County, Pa.

D. White "shale clay" associated with limonite one-fourth mile northwest of Guth station, South Whitehall, Lehigh County, Pa.

The significance of these analyses and microscopic examinations is that this slate in weathering first loses its carbonate, then its carbonaceous matter, then its pyrite, and has its feldspathic material, if any, changed to kaolin, while its muscovite remains partly unaltered and its quartz largely so. The bleaching process in the slates of Lehigh and Northampton counties, Pa., apparently proceeds by these steps:

1. Removal of carbonates of lime and magnesia, accompanied by oxidation of the ferrous carbonate and deposition of limonite.
2. Oxidation and removal of carbon; also oxidation and removal of pyrite.
3. Removal of almost all limonite.

In general, therefore, while slate in weathering returns to a clay, this clay differs from that in which the slate must have originated, in some places by the absence of carbon and the small amounts of silica, potash, and soda, and in others by the absence or extremely low percentages of carbon, lime, and iron.

CHEMICAL COMPOSITION OF THE ROOFING SLATES OF EASTERN NEW YORK AND WESTERN VERMONT.

By W. F. Hillebrand.

Before the analyses of any of the slates were undertaken, it was well understood that the chief question of economic importance to be solved was the cause of fading observed in some but not all of the green slates after longer or shorter exposure to atmospheric influences. Attention was therefore primarily directed toward its elucidation, and the evidence accumulated will be herein set forth. Naturally, in the course of the work, opportunity was afforded for drawing conclusions as to the combination of certain chemical elements concerning which the microscope could furnish no satisfaction. A few remarks in this connection may therefore well be in place.

It soon became clear that there was no apparent connection between the percentage of iron sulphide (FeS_2) in any green slate and its liability to fade; that, furthermore, the visible sulphide was of an extremely resistant type, and often after years of exposure retained its original luster undimmed; that it was probably true pyrite. The possibility remained that there might be finely divided FeS_2 in the much more readily decomposable form of marcasite. Microscopical evidence made it clear that if present at all it was in amount altogether too trifling to produce the fading effect often observed.

It was found that the ferrous iron, other than that in the pyrite, was almost entirely in very soluble condition. Even when carbonates were absent, a large proportion of it dissolved in moderately dilute acids after very few minutes boiling. But the ferrous iron thus shown to exist in the silicate minerals could not be accepted as the cause of fading, because it exists in all slates; and some of the most ferruginous, as 314*f*,[1] are "unfading." Microscopical evidence is also opposed to oxidation of ferrous silicates as the cause of fading.

There remained as its sole probable cause the carbonate found in nearly all the slates. Its chemical behavior toward acids proves beyond question that this carbonate can be in no observed case calcite. Were it even in small part calcite, an instantaneous disengagement of gas would be apparent on adding acids, whereas their action is tardy and becomes pronounced only on application of heat. To those familiar with the behavior of different carbonates this evidence alone is decisive.

The carbonate is, therefore, an isomorphous mixture, and indeed the CO_2 found, as compared with the CaO, shows at once a great excess of the former. That $CaCO_3$ is one of the chief isomorphous constituents appears from the fact that absence of CO_2 uniformly accompanies the lowest percentages of CaO, and that increase of CaO carries with it an approximately corresponding increase of CO_2. The CO_2 is usually in molecular excess of the CaO, and in some slates of the MnO and FeO as well (compare analyses L, M, Q, R); hence $MgCO_3$ is indicated as the next most important isomorphous element of the carbonate. Analyses M, Q, and R, taken together in the order named, afford positive evidence that $MnCO_3$ is present either as an independent mineral or as a component of the complex carbonate, for as CO_2 decreases from the green center through the purple rim to the outer red, so does MnO, and at such a rate that with no carbon dioxide MnO would likewise disappear. In general, too, the slates high in CO_2 show a relatively high MnO content. Analysis 201*d* shows also that manganese carbonate is found as a vein formation in the slates, and Mr. Dale has found with the microscope some indications of its presence in the lenses of the red slate, at least. In order to be able to credit the fading to the carbonate, it is necessary still to show that it contains $FeCO_3$ as a constituent, for, while the manganese might produce discolorization by oxidizing, its amount is slight, and the color due to its oxidation products alone would be black rather than brown. Because of the above-mentioned ready solubility of the ferrous silicate or silicates in acids, chemical proof of the presence of ferrous carbonate is not obtainable, but from our general knowledge of its relations to those of magnesium and manganese it is in the highest degree probable that it does exist either as a distinct mineral or as a component of the dolomitic carbonate, and, in fact, it would be somewhat surprising if, with magnesium and manganese present as carbonates, iron should be absent. The needed proof, however, is supplied by the microscope, as detailed in the text of Mr. Dale's report (p. 140).

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[1] Numbers refer to specimens whose analyses are given in the local desc[illegible]

If it is objected that some green slates comparatively rich in carbonate fade less than others which are much poorer, it may be reasonably urged that the relative proportions of the several carbonates are doubtless subject to change in different slates, as in the natural order of things they must be, for the original composition of the slate-forming materials must have differed in each locality. This being so, it follows that a mere test as to the relative amount of CO_2 can furnish no guide in advance as to the fading qualities of a slate, as it might were the composition of the mixed carbonates always constant.

Though pyrite is never a visible constituent of the red slates, its presence seems necessary to account for the sulphur found, for careful tests failed to show an equivalent amount by far of SO_3. Hence pyrite is reported in all the analyses.

The phenomenal percentage of barium in 201*e* (K), as compared with other slates, has been of service as showing that, in this slate at least, it is mainly if not altogether a constituent of some silicate or silicates and not of barite only, which, according to Mr. Dale, has been observed on joint planes and in crystalline concretions, for the sulphur is totally inadequate to form barite with all the barium.

The condition of the nickel and cobalt has not been definitely ascertained. From the analysis of the manganese carbonate 201*d* it might appear as if they were constituents of the carbonate in the slates, but it is not impossible that they may be in combination with arsenic, or with arsenic and sulphur, as arsenides and sulpharsenides, even if the presence of arsenic has not been revealed, no test having been made for that element. In all the tests made for nickel and cobalt, both elements were found, and in one test their combined percentage as oxides, probably a maximum, was 0.025.

Heating of the slates in tubes closed at one end gave without exception alkaline vapors and whitish sublimates, and the latter reacted for SO_3, Cl, and strongly for NH_3. In eight tests the amount of ammonia thus given off in both conditions was ascertained by nesslerization and found to range from 0.0075 per cent for 760*a* (H) to 0.04 per cent for 305*d* (P). The latter is a black slate carrying nearly 0.5 per cent of carbon, but the ammonia obtained was not sensibly higher than in some of the green slates, as 645*a* (F) with 0.035 per cent NH_3, or 314 of 1895 (I); with 0.03 per cent NH_3.

Neither the condition nor the source of the nitrogen thus revealed can be stated with any degree of positiveness. It is found in the interior of fresh and unbroken masses and hence is not to be regarded as derived from infiltration of nitrogenous matter since the opening of the quarries. Whatever may be its manner of combination, nitrogen is coming to be recognized as a primary constituent of many rocks and minerals. It seems probable that its presence in these slates is to be attributed to the organic matter which was doubtless not wanting when the materials now composing the slates were originally laid down.

Chromium and vanadium are probably minor constituents of all the slates. They were not looked for in making the foregoing analyses, but in connection with some more recent work relating to the distribution of vanadium in the rocks of the earth's crust[1] the sea-green slate 230*a* (A) and the red slates 201*e* (K) and 397*e* (L) were examined. In 201*e* there was found 0.017 per cent of vanadium as V_2O_5 and 0.007 per cent of chromium as Cr_2O_3. A mixture of equal parts of the two red slates was found to contain 0.008 per cent V_2O_5 and about as much Cr_2O_3 as in 201*e*.

To the novice a cursory examination of the tabulated analyses might seem to indicate a greater diversity in essential composition than comports with the facts. Thus there seems to be, perhaps, little relation in composition, except qualitatively, between the red slates 358*d* (J) and 397*e* (L). Yet, after deducting all CaO as phosphate and carbonate, all MnO as carbonate, and enough MgO as carbonate to satisfy the remainder of the CO_2, also the trace of pyrite, amounting to 16.58 per cent in all, and calculating the remaining 83.80 per cent to 100, we obtain the figures given in the first column below, for comparison with which analyses 358*d* (J) and 201*e* (K) of slates naturally altogether or nearly free from carbonates are partly reproduced:

	397*e* (L).	358*d* (J).	201*e* (K).		397*e* (L).	358*d* (J).	201*e* (K).
SiO_2	67.40	67.61	67.55	K_2O	4.50	4.45	4.13
TiO_2	.57	.56	.58	Na_2O	.62	.67	.61
Al_2O_3	13.84	13.20	12.59	H_2O below 110° C.	.44	.45	.40
Fe_2O_3	4.15	5.36	5.61	H_2O above 110° C.	3.37	2.97	3.03
FeO	1.70	1.20	1.24				
BaO	.07	.04	.31		100.00	99.71	99.32
MgO	3.34	3.20	3.27				

When it is borne in mind that a portion of the FeO in 397*e* should doubtless be credited to the carbonate, whereby an equivalent of MgO would be released for the silicate, it will be seen that the agreement as to FeO in the above comparison would be much closer, and the three slates may be said to have almost identically the same composition when compared in this manner.

Applying a similar correction to the three analyses of 397*a* R, Q, and M, in the order named, we obtain the following corrected figures for the green spot, the purple rim, and the outer red, which bring into special prominence their relatively high silica contents as compared with all the other slates analyzed:

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[1] Distribution and quantitative occurrence of vanadium and molybdenum of rocks in the United States, by W. F. Hillebrand: Am. Jour. Sci., 4th ser., vol. 6, p. 209, 1898.

	397*a* (R).	397*a* (Q).	397*a* (M).		397*a* (R).	397*a* (Q).	397*a* (M).
SiO_2	76.04	73.64	71.59	K_2O	4.15	4.22	3.87
Tio_2	.60	.58	.53	Na_2O	.26	.26	.22
Al_2O_3	10.90	11.66	10.95	H_2O below 110° C.	.29	.32	.30
Fe_2O_3	1.27	2.04	4.33	H_2O above 110° C.	2.45	2.61	2.78
FeO	1.23	1.36	1.61				
BaO	.06	.05	.05		100.00	99.99	100.00
MgO	2.75	3.25	3.77				

The foregoing calculations for 397*e* and 397*a* (L and M) show at the same time the general dolomitic character of the carbonate, as appears from the following table, wherein the percentages of carbonates are given as calculated on the above-predicated assumptions:

	397*e* (L).		397*a* (R).		397*a* (Q).		397*a* (M).	
	Percentage.	Molecular ratio.	Percentage.	Molecular ratio.	Percentage.	Molecular ratio.	Percentage.	Molecular ratio.
$CaCO_3$	8.95	1.03	7.93	1.15	7.11	1.16	6.14	1.15
MgCO	6.93	1.00	5.36	1.00	4.77	1.00	4.22	1.00
$MnCO_3$	.48		.57		.47		.38	
	16.38	....	13.86	....	12.35	....	10.74	....

If, as is quite probable, a small fraction of the CaO should be charged to the silicates, the true dolomitic ratio would be more closely approached. It is of no consequence for the above calculations that an undeterminable portion of $FeCO_3$ should appear as $MgCO_3$. The ratios are not thereby affected.

PART II.—SLATE DEPOSITS OF THE UNITED STATES.

In Part II of this paper each State is taken up in alphabetic order. In the description of a deposit that has not been especially examined by the writer or some other geologist the result of the writer's microscopic examination is accompanied by such geologic data as could be found in the geologic literature of the region.

ARIZONA.

A specimen of roofing slate received from Arizona came from a deposit reported as about 6½ miles north of Phoenix and said to measure 800 to 1,000 feet in width and about 5,000 feet in length.

Lee[1] refers to the geology of this locality as follows:

> In the Phoenix Mountains, immediately north of the city of Phoenix, occurs an extensive series of metamorphosed sediments, many thousands of feet in thickness. The layers rest in a nearly vertical position.

Lee's map shows areas of Algonkian rocks along the foot of the Phoenix Mountains at points ranging from 6 miles N. 25° E. to 7 miles north of Phoenix.

The examination of the specimen yielded the following results:

It is bluish gray with a lustrous surface, marked by two sets of minute wrinkles that lie at right angles to each other, a coarser set numbering from 25 to 40 per inch and a finer set numbering many more. The slate breaks along the finer set much more readily than along the coarser set. It has a marked argillaceous odor, shows considerable pyrite on the sawn edge, contains but little magnetite, does not effervesce in cold dilute hydrochloric acid, is sonorous, and has a fair grade of fissility.

Under the microscope this slate shows a matrix[2] consisting of muscovite (sericite) with a brilliant aggregate polarization.[2] Cleavage and bedding foliations are parallel but are crossed by two incipient slip cleavages (see p. 37 and Pls. VII, XI, *A*), the plications of which have not resulted in fractures but which give the slate a somewhat schistose structure. The finer of these slip cleavages has from 100 to 150 plications to the inch. There is considerable quartz, which appears to be mostly secondary. The conspicuous feature, however, is the great abundance of lenses and particles of pyrite and hematite. In the cross sections these measure from 0.0043 to 0.043 millimeter in length by 0.002 to 0.008 millimeter in width and number about 800 per square millimeter.[3] In parallel section they have irregular angular-roundish outlines.

There are also large plates of muscovite, a few crystals of tourmaline, a few lenses of decomposed crystals of an undetermined mineral up to 0.0425 by 0.025 to 0.075

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[1] Lee, W. T., Underground waters of Salt River valley, Arizona; U. S. Geol. Survey Water-Supply Paper 136, p. 96, Pls. VII, VIII, 1905.

[2] For definitions of technical terms see Glossary, pp. 213-215.

[3] The square millimeter referred to comprises the thickness of the thin section.

millimeter, and considerable rutile in very minute prisms. No carbonate was detected.

The constituents of this slate, arranged in descending order of abundance, appear to be muscovite, quartz, pyrite, hematite, kaolin, magnetite, rutile, and tourmaline.

If properly cut with reference to the direction of weakness this may prove a serviceable slate, but slip cleavage is generally objectionable. In this slate the slip cleavages are, however, only incipient.

ARKANSAS.

TOPOGRAPHY, GEOLOGY, AND CHARACTER OF DEPOSITS.[1]

The slate area of Arkansas covers part of the Ouachita Mountains, which lie south of Arkansas River and have a general east-west trend. The area extends from the vicinity of Little Rock about 100 miles westward nearly to Mena, and has an average width of 15 miles. The rocks include shales, slates, chert, novaculite (a deposit of extremely fine quartz grains), sandstone, and a little limestone. The entire sedimentary series is estimated at 11,400 feet in thickness, of which the upper 8,825 feet contains some commercial slate, as shown in the table below:

Section in Arkansas showing the relations of slates.

	Feet.
Carboniferous:	
Stanley shale: Greenish clay shale, locally black slate near the base, and greenish quartzitic sandstone	6,000
Unconformity.	
Age unknown:	
Fork Mountain slate: Gray slate with thin beds of siliceous material	125
Arkansas novaculite: Massive white and variegated novaculite with alternating flint and shale layers in the upper half	800
Missouri Mountain slate: Mainly red slate with green slate in basal part	75–300
Ordovician:	
Blaylock sandstone: Greenish quartzitic sandstone alternating with brownish-black shale	0–1,500
Polk Creek shale: Black fissile and sandy graptolitic shale	0?–100
Bigfork chert.	
	8,825

The areal distribution of these formations is shown on the geologic map (Pl. III) of Purdue's report on the slates published by the Geological Survey of Arkansas in 1909. The general situation of the slate district is shown in E. C. Eckel's map (Plate IX of this bulletin).

These strata lie in parallel close folds with the east-west axes which pitch alternately but always together east and west. The folds are either erect or overturned to the north or south. The peculiar topography of the region is due to these parallel pitching folds and to the unequal resistance offered to erosion by the soft shales and slates and by the hard quartzose beds.

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[1] Summary from Purdue, A. H., The slates of Arkansas: U. S. Geol. Survey Bull. 430, pp. 317–334, 1910.

Slate of possible economic value occurs in the four formations mentioned below.

The Polk Creek shale passes here and there into a black graptolitic sonorous slate, in places banded. The smallness of the amount of slate and the abundance of joints throughout the formation make the deposit of doubtful economic value.

The Missouri Mountain slate has been extensively prospected and is now quarried at Slatington. Its structure on Fork and Missouri mountains is shown in figure 4. It produces both red and green slate, the former predominating. In some places the cleavage is parallel to the bedding; in others it is oblique. The slate is defective in sonorousness and in many places shows two sets of slip cleavage.

This slate is used for mill stock, particularly laundry tubs, lavatories, wainscoting, and electric switchboards. The results of tests of its electric conductivity are given beyond. In the preparation of millstock there is a certain loss from worked pieces cracking either along or at right angles to the cleavage.

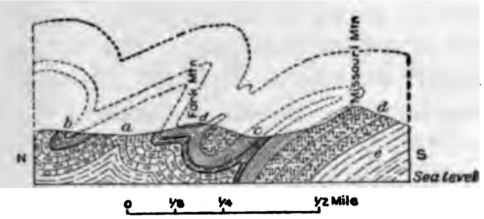


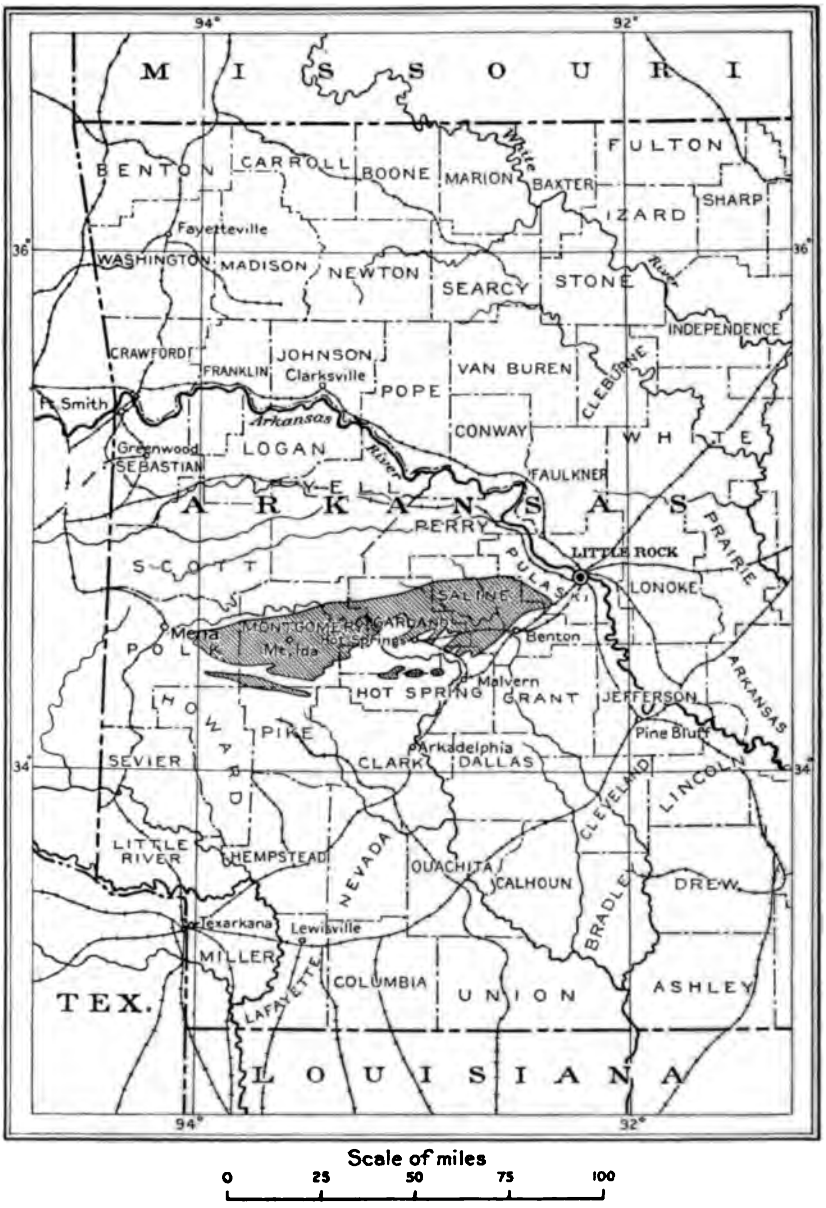
FIGURE 4.—North-south section through Fork Mountain, Ark., T. 3 S., R. 28 W., showing the folded structure of the Missouri Mountain slate. *a*, Bigfork chert; *b*, Polk Creek shale; *c*, Missouri Mountain slate; *d*, Arkansas novaculite; *e*, Stanley shale. From A. H. Purdue, U. S. Geol. Survey Bull. 430, fig. 6, 1910.

The Fork Mountain slate consists of a hard slate, generally gray but weathering in places green or chocolate color and containing many thin sandy beds. The slate usually has a good cleavage and is ribboned, highly sonorous, strong, and tough. So far as prospected it is too much jointed to be of economic value.

The Stanley shale is almost everywhere a shale, rarely a slate. It has been extensively prospected near Slatington and in the southwestern part of Polk County. The color of the slate is blue to black and its cleavage remarkably fine, with very smooth cleavage surfaces. It is not regarded as sufficiently durable for roofing. Two quarries have been opened in it.

CHEMICAL COMPOSITION OF THE SLATES OF ARKANSAS.

The following analyses of slates from Arkansas, published in E. C. Eckel's note on slates of Arkansas in Bulletin 275, are fairly representative of the composition of some of these slates:



MAP SHOWING SLATE AREA OF ARKANSAS.

By E. C. Eckel.

Analyses of slates from Montgomery County, Ark.

[Analyst, W. G. Waring.]

	1	2	3	4	5	6	7
Silica (SiO_2)	66.16	68.79	69.04	69.07	67.90	64.00	63.22
Alumina (Al_2O_3)	8.62	14.26	12.66	11.40	10.42	11.59	16.76
Ferric oxide (Fe_2O_3)	9.04	5.90	8.55	7.66	6.22	13.71	9.54
Ferrous oxide (FeO)	3.44	1.16	1.30	1.04	....	....	....
Lime (CaO)	1.77	1.40	1.75	1.56	3.17	1.56	1.75
Magnesia (MgO)	.78	1.43	1.87	3.14	4.34	2.03	1.52
Potash (K_2O)	4.96	3.09	2.98	3.88	4.11	1.36	1.43
Soda (Na_2O)	.64	.09	.09	.96	.60	.64	.70
Sulphur in SO_3	.08	.44	.06	.02	.06	.05	.05
Sulphur in FeS_2	.02	.01	.01	.01	.01	.04	.03
Carbon (C)	2.10	2.01	Tr.	....	1.78	4.03	3.70
Carbon dioxide (CO_2)	.09	.11	.72	.11	.01	.01	.01
Water (H_2O)	.18	.47	.84	.24	.23	.57	1.01

1. Green slate, quarry No. 2.
2. Red slate, quarry No. 2.
3. Red slate from State House Cove.
4. Hard red slate from State House Cove.
5. Green slate from State House Cove.
6. Black slate from west end of Crooked Creek vein.
7. Black slate from Crooked Creek Falls.

MICROSCOPIC ANALYSES OF SLATES FROM ARKANSAS.

The microscopic analyses of slates from Arkansas published in 1904[1] are here repeated and supplemented by several others of specimens collected by Mr. Eckel during his visit to the quarries of that State in 1905. All have been revised.

Black slate from Mena, near Big Fork. This is a pure black slate, which to the unaided eye has an exceedingly fine texture and a remarkably smooth cleavage surface with a slight luster. It is both carbonaceous (or graphitic) and magnetitic; does not effervesce with cold dilute hydrochloric acid, is very sonorous and very fissile. Under the microscope this slate shows a matrix of muscovite (sericite), with a very brilliant aggregate polarization and an unusually fine texture and great homogeneity. Quartz grains are few and not over 0.01 millimeter in diameter. Rutile needles unusually minute. Many opaque particles of irregular shape, some of which are pyrite, others magnetite, and some coaly or graphitic matter. No carbonate.

The constituents, arranged in descending order of abundance, appear to be muscovite, carbonaceous or graphitic matter, quartz, pyrite, magnetite, and rutile.

This is a mica slate, with a remarkably fine cleavage and not liable to discolor on exposure, but its strength and its behavior under frost should be tested.

Dark-reddish slate from Mena, near Big Fork. In color this slate is somewhat darker than the "red" slate of New York. To the unaided eye it has a minutely granular texture and a roughish, speckled, almost lusterless surface. Contains very little magnetite, does not effervesce with cold dilute hydrochloric acid, is sonorous, splits readily, and has some argillaceous odor. Under the microscope it shows a matrix of muscovite (sericite), with brilliant aggregate polarization, quartz grains ranging up to 0.025 millimeter, muscovite and chlorite scales, and abundant hematite in minute dots. There are also rhombs, from 0.1 to 0.2 millimeter, of chlorite and rhodochrosite, probably pseudomorphs. No other carbonate.

The constituents, arranged in descending order of abundance, appear to be muscovite, hematite, kaolin, quartz, chlorite, rhodochrosite (?), and magnetite.

This slate compares favorably in texture with the "red" slate of New York.

Reddish slate from the Missouri Mountain slate ("Mammoth red" and "Lost Hannah" of quarrymen; exact locality not given). Color lighter than above, but not quite so red as the New York slate. To the unaided eye has a fine texture and a fine cleavage surface but no luster. Contains very little magnetite; does not effervesce with cold dilute hydrochloric acid, is sonorous and fissile, has some argillaceous odor.

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[1] U. S. Geol. Survey Bull. 225, p. 414.

Under the microscope it shows a matrix of muscovite (sericite), with brilliant aggregate polarization, quartz grains up to 0.03 millimeter, muscovite and chlorite scales, abundant hematite pigment, and no carbonate.

The constituents, arranged in descending order of abundance, appear to be muscovite, hematite, kaolin, quartz, chlorite, and magnetite.

This is a finer and softer slate than the dark red and should be tested for strength and frost resistance.

Greenish-gray slate from Mena. In color this resembles the sea-green slate of Vermont. To the unaided eye it has a fine texture, a roughish cleavage surface, and a waxy luster; does not show pyrite on sawn edge, contains very little magnetite; does not effervesce with cold dilute hydrochloric acid, and is somewhat sonorous.

Under the microscope it shows a matrix of muscovite (sericite), with a brilliant aggregate polarization and is of very fine texture and homogeneity, but the cleavage is crossed at an angle of 13° by a very close bedding foliation and also by an obscure slip or false cleavage at about 40°. Contains very few and very minute quartz grains, no carbonate, several pseudomorphic rhombs of chlorite, 0.08 millimeter, and has a slight argillaceous odor.

The constituents, arranged in descending order of abundance, appear to be muscovite, quartz, kaolin, chlorite, and magnetite.

The two extra foliations are likely to prove directions of weakness.

Light-greenish slate from the Missouri Mountain slate ("Mammoth red"), locality not designated. This is more greenish than the above; to the unaided eye has an exceedingly fine texture and a very fine, almost lusterless cleavage surface; shows pyrite on sawn edge; contains a little magnetite; does not effervesce with cold dilute hydrochloric acid, is sonorous, very fissile, and has a slight argillaceous odor.

Under the microscope it shows a matrix of muscovite (sericite), with a brilliant aggregate polarization and great evenness of texture. A very minute bed of quartz grains, chlorite, and muscovite lies in the cleavage, which is therefore the bedding also. The grain is indicated by the transverse position of some of the muscovite scales. Quartz not very abundant but occurs in grains up to 0.037 millimeter. Rutile needles abound from 0.0028 by 0.0009 up to 0.014 by 0.0014 millimeter. Muscovite and chlorite scales occur, the latter producing the green color. There are some opaque granules (limonite? and pyrite), occasional lenses, 0.14 millimeter long, of a central mass (probably rhodochrosite), with secondary muscovite at both ends. No other carbonate. Shows a number of tourmaline prisms up to 0.025 by 0.008 millimeter.

The chief constituents, arranged in descending order of abundance, appear to be muscovite, quartz, kaolin, chlorite, rutile, pyrite, magnetite, and tourmaline.

This mica slate probably possesses more petrographic interest than economic value. Its fissility, freedom from carbonate, and color are very favorable, but it will probably be found too delicate for use on a roof.

Very dark bluish-gray slate from sec. 25, T. 3 S., R. 29 W. (Specimen collected by E. C. Eckel.) To the unaided eye this slate has a fine texture and a smooth cleavage surface with a little luster, and shows a little pyrite on the sawn edge. It contains very little magnetite, considerable carbonaceous or graphitic matter, does not effervesce with cold dilute hydrochloric acid, is sonorous, and has a high grade of fissility. Under the microscope it shows a fine-textured matrix of muscovite (sericite) with good aggregate polarization, but somewhat obscured by carbonaceous matter. Quartz is not abundant, the grains measuring up to 0.047 by 0.02 millimeter. Pyrite spherules, measuring up to 0.008 millimeter in diameter, number about 120 per square millimeter. There are rutile needles but no carbonate.

The chief constituents, arranged in order of decreasing abundance, appear to be muscovite, quartz, pyrite, carbonaceous or graphitic matter, and rutile.

This slate has absence of carbonate in its favor. It is not so fine textured or so fissile as the black slate from Mena (p. 63), but may prove more durable.

Light-gray slate with a slightly greenish tinge from sec. 30, T. 3 S., R. 28. W. (Specimen collected by E. C. Eckel.) To the unaided eye this has a fine texture, but a lusterless, roughish surface, and shows a little pyrite on the sawn edges. It contains an insignificant amount of magnetite but no carbonaceous or graphitic matter, does not effervesce with cold dilute hydrochloric acid, and has an argillaceous odor and a fair degree of fissility and sonorousness.

Under the microscope it shows a fine-textured matrix of muscovite (sericite) with brilliant aggregate polarization, containing not abundant quartz grains, measuring up to 0.03 millimeter, scales of chlorite and of muscovite transverse to cleavage, some pyrite cubes up to 0.063 millimeter (generally with a rim of secondary quartz), passing into limonite and staining the matrix. Rutile needles abound.

The chief constituents, arranged in decreasing order of abundance, appear to be muscovite, quartz, chlorite, kaolin, pyrite, rutile, and limonite, with accessory magnetite.

Whether the limonitic staining from the decomposition of the pyrite will produce any appreciable discoloration in the course of years can be determined only by experiment.

Very dark-gray spangled slate from quarry operated by the Southwestern Slate Manufacturing Co. (Specimen collected by E. C. Eckel.) To the unaided eye this has a coarsish texture and a roughish, almost lusterless surface, spangled with minute scales of mica, shows pyrite on sawn edges, contains very little magnetite and little carbonaceous matter, does not effervesce with cold dilute hydrochloric acid, is somewhat sonorous, tolerably fissile, and has a slight argillaceous odor.

Under the microscope it shows a fine-textured matrix of muscovite (sericite) with brilliant aggregate polarization, containing roundish and angular grains of quartz of variable and large size, up to 0.27 by 0.17 millimeter; also a few of plagioclase feldspar, scales of muscovite and biotite up to 0.2 by 0.1 millimeter, some lenses of carbonate up to 0.4 millimeter long, a few grains of tourmaline, and lenses of secondary quartz. There is a faint incipient slip cleavage, not apparent, however, in the hand specimen.

The chief constituents of this slate, arranged in order of decreasing abundance, appear to be muscovite (including sericite), quartz, carbonate, pyrite, carbonaceous matter, and kaolin, with accessory biotite, plagioclase, tourmaline, and magnetite.

This slate combines some of the features of a metamorphic graywacke or grit with those of a mica slate. It is inferior to the dark bluish-gray slate described above.

PHYSICAL AND ELECTRIC TESTS.

The results of elaborate physical and electric tests of some of these slates, made for Purdue's report, will be found in full in Part III, pages 184–187.

CALIFORNIA.

ELDORADO COUNTY.

By Edwin C. Eckel.

Location and general relations.—Though roofing slate has at different times been quarried on a small scale in other parts of California, the only important slate-producing area in the State is located in

Eldorado County. The quarries which have been opened in this district are located along a line running about N. 15° W. from Placerville, at distances of 1 to 6 miles from that town. The location and geographic and geologic relations of the slate deposits and quarries can best be understood by reference to the maps included in the Placerville folio of the United States Geological Survey. The workable roofing-slate deposits of this district occur in a belt of the Mariposa slate, of Jurassic age. The quarries which have been opened are all situated near the western boundary of this belt of Mariposa slate where it is bordered by a large area of diabase. This diabase, according to Lindgren and Turner, is "of the age of the Mariposa slate, or older." A number of linear areas of amphibolite occur in the Mariposa slate. These amphibolites are described as being derived from diabase or gabbro. They are in part altered to serpentine.

Previous work on the slate deposits.—The Placerville folio[1] contains the results of detailed geologic work by Lindgren and Turner in the area in which the roofing-slate deposits occur. At that date the roofing-slate industry had not assumed its present importance, though all the quarries now worked had then been opened. The existence of roofing-slate deposits is noted in the text of the folio, and the locations of the quarries are indicated on the map showing the economic geology of the area. No reference is made to the "green slates," or to the dikes cutting the Eureka quarry.

Excellent though brief descriptions of the different quarries and of the condition of the slate industry at various dates are to be found in the reports of the State mineralogist of California, particularly in the eighth and twelfth reports. The geologic relations of the slate-producing areas are shown on Plate X.

Structural relations in Eureka quarry.—At present the most important quarry is that of the Eureka Slate Co., and this is now being worked on a large scale. This quarry is at Slatington, about half a mile southwest of Kelsey. The cleavage planes of the slates strike N. 25° W. The dip of the cleavage is practically vertical, with slight local variations to 80° E. or 80° W. The upper weathered beds in the quarry are overturned by local pressure so as to give dips of 40° to 60° to the east or west, according to local conditions. This overturning is evidently due merely to the weight of the overlying soil and decomposed slate, and the effects are shown only for a depth of 3 to 15 feet. It is of interest, however, as a warning against accepting dip readings taken from surface beds of the slate.

The slate body shows rather numerous but narrow "ribbons." These ribbons are bands (from one-sixteenth to one-half inch thick

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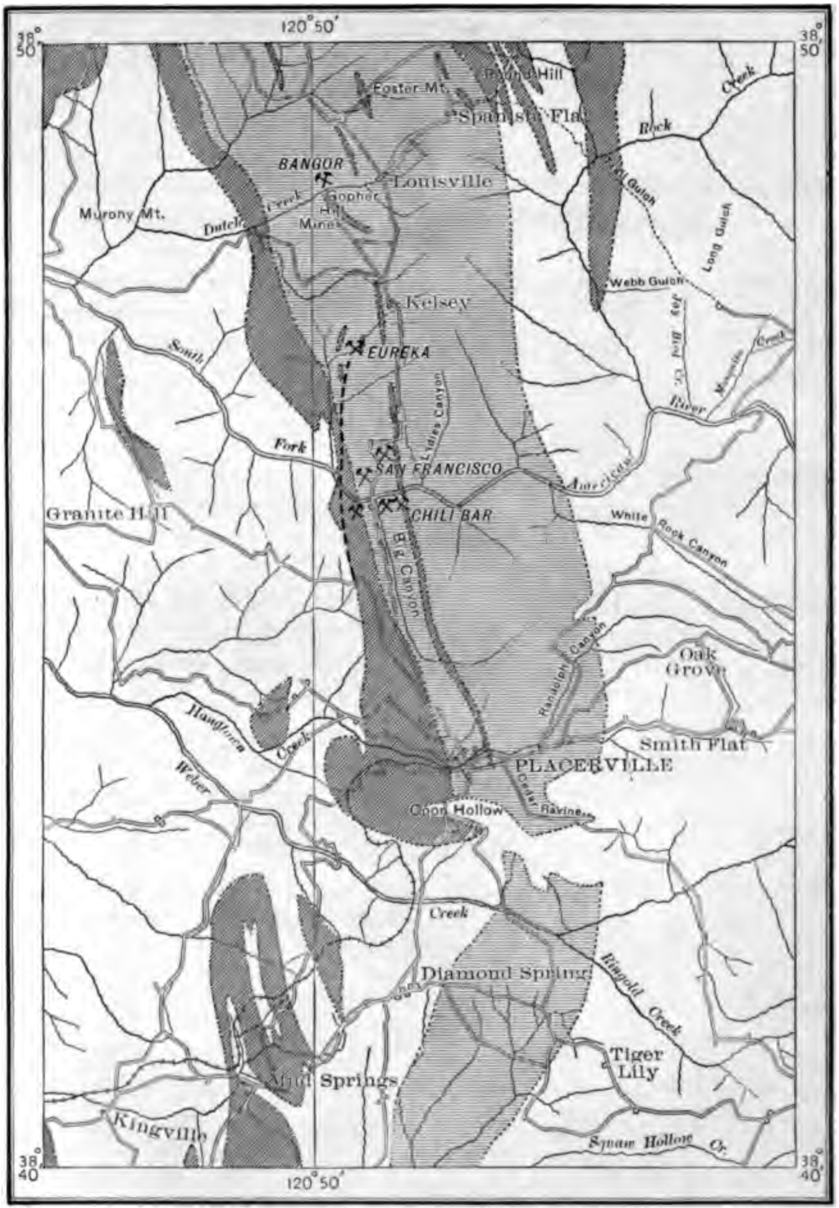
[1] U. S. Geol. Survey Geol. Atlas, Placerville folio (No. 3), 1894.



GEOLOGIC MAP OF PLACERVILLE SLATE DISTRICT, CALIFORNIA.

Scale

0 1 2 3 4 miles

▤ **Mariposa slates**

■ **Basic igneous rocks**

⚒ **Slate quarries**

------ **Line of cable**

From U. S. Geol. Survey Geol. Atlas, folio 3.

usually, but locally as thick as 2 inches) of material differing in composition from the mass of the slate. They are in general more siliceous than the normal slate and do not furnish merchantable material. Their geologic interest arises from the fact that they represent differences in original sedimentation. The plane of the ribbons in a slate quarry is therefore the plane of original bedding. In the Eureka quarry and indeed throughout the roofing-slate belt the plane of original bedding seems to be usually within 10° of the plane of slaty cleavage.

The slate mass is cut by a series of joints parallel to the grain of the slates, striking N. 55° E. and dipping 70°–80° NW. Joints across the grain of the slate, which would be practically horizontal, do not occur in this quarry, but many of the thin quartz seams occupy this position.

Quartz and calcite occur in thin layers, filling joint spaces and some cleavage spaces. Pyrite also occurs in very much flattened nodules, which were apparently parallel to the original bedding.

Character of the normal slate.—The mass of the Eureka quarry product is a dense deep-black slate, splitting very finely and regularly, with a smooth glistening surface, much like that of the slates of Lehigh and Northampton counties, Pa. The abundance of the ribbons and of the pyrite nodules prevents the slate from being serviceable as mill stock, but as a roofing material it is excellent.

A specimen of the black slate, free from ribbon, was selected for analysis in the laboratory of the United States Geological Survey. The results of this analysis, by W. T. Schaller, follow:

Analysis of black slate from Eureka quarry, Slatington, Cal.

Silica (SiO_2)	63.52
Alumina (Al_2O_3) and titanic oxide (TiO_2)	16.34
Iron oxides (FeO, Fe_2O_3)	6.79
Lime (CaO)	.98
Magnesia (MgO)	2.50
Carbon dioxide (CO_2) Water	4.86

T. Nelson Dale has reported as follows on a sample of this slate:

> This slate is very dark gray. To the unaided eye it has a fine texture and a smooth and lustrous cleavage surface. It contains considerable carbonaceous or graphitic matter but extremely little magnetite. The sawn edges show pyrite and lenses and streaks of lighter-gray material. There is no effervescence in cold dilute hydrochloric acid. It is sonorous and has a high grade of fissility.
>
> Under the miscroscope it shows a matrix of muscovite (sericite) with a brilliant aggregate polarization and a general evenness of texture, interrupted, however, by lenses up to about 3 millimeters long by about 0.5 millimeter wide, consisting chiefly of quartz fragments (surrounded by a rim of radiating secondary quartz) with muscovite scales, plates, and rhombs of carbonate, and rarely a grain of plagioclase. These lenses have their long axes parallel to the cleavage, but in sections parallel to it some

of them have such irregular outline and are so large as to appear like minute beds. The matrix contains many quartz fragments, measuring up to 0.09 by 0.03 millimeter, much less carbonate than the lenses, muscovite scales, chlorite scales, a little pyrite in spherules and crystals, carbonaceous or graphitic matter, rutile needles, a few grains of tourmaline, and rarely one of zircon.

The main constituents of this slate, arranged in order of decreasing abundance, appear to be muscovite, quartz, chlorite, carbonate, pyrite, carbonaceous matter or graphite, rutile, and magnetite, besides accessory tourmaline and zircon.

This ought to prove a serviceable slate. It will be noticed that carbonate, although present, is insufficient to produce effervescence.

Green slate of Eureka quarry.[1]—A band of green slate several feet wide crosses the Eureka quarry. On examination it is found that the borders of this band are not parallel to the ribbon of the black slate. The green band can not, therefore, be interbedded with the black slate. The probability that it represents a dike of massive igneous rock which has been changed to a slate by pressure subsequent to its intrusion is strengthened when the chemical composition of the green slate is considered. Two analyses of the green slates are presented below. The first is of a sample selected by the writer and analyzed in the laboratory to the United States Geological Survey by W. T. Schaller; the second was given by Mr. C. H. Dunton, manager of the Eureka quarry, but the name of the analyst is unknown. As the analyses show a close agreement in essential features, it is probable that they are fairly representative of the composition of the green slate, and that their average, which is given in the third column of the table, may be regarded as typical of this interesting and apparently unique type of roofing slate.

Analyses of igneous green slate from Eureka quarry, Slatington, Cal.

	1	2	Average.
Silica (SiO_2)	45.15	47.30	46.22
Alumina (Al_2O_3)	16.33	15.53	15.93
Iron oxides (FeO, F_2O_3)	8.42	8.00	8.21
Lime (CaO)	6.42	7.83	7.12
Magnesia (MgO)	8.72	7.86	8.29
Sulphur (S)	([a])	.12	.12
Alkalies (K_2O, Na_2O)	([a])	3.17	3.17
Carbon dioxide (CO_2)	11.28	9.92	10.60
Water (H_2O)			

[a] Not determined.

These analyses have been compared[2] with a series of 36 analyses of American roofing slates derived from clays by pressure, and remarkable differences in composition are apparent. The green slate, on the other hand, approximates closely in composition certain "basic" igneous rocks of the district, and it is probable that it was derived from a gabbro or similar rock.

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[1] For a more detailed discussion of this interesting "igneous slate" the reader is referred to a paper by the writer in the Journal of Geology, vol. 12, pp. 15-29, 1904.

[2] Jour. Geology, vol. 12, p. 26, 1904.

The "green slate" is in reality grayish green in color. It splits readily, though with not so smooth a surface as the black slate. It stands punching and trimming well and is sufficiently strong for roofing use. Considering its origin and composition, it is probable that it will be a highly durable slate, holding its color well. At present it is sold entirely for trimming and lettering on black slate roofs, for which purpose it is particularly well adapted, giving a strong but pleasant color contrast.

Chili Bar Slate Co.'s quarry.—This quarry is located about 3 miles north of Placerville, in sec. 36, T. 11 N., R. 10 E., on the south side of the South Fork of American River, a few hundred yards east of the Placerville-Kelsey stage road. It is the oldest quarry in the district, having been opened about 28 years ago. It has been shut down since 1897.

Several openings were made in a bluff forming the river bank at this point. In the easternmost of these openings, which is about 40 feet high and 30 feet wide, a rather poor slate with irregular joints is shown. The cleavage strikes N. 20° W. and dips 75° E. The westernmost opening is small and consists of a tunnel which was apparently run in on a band of better slate. The slate piled in the yard has kept its color fairly well.

It seems possible that this quarry may be flooded at high water. Both it and the one next mentioned (San Francisco quarry) are badly located, having no large dumping areas available near by. Neither quarry has gone deep enough to get really good slate, which might have been found at a greater depth.

San Francisco Slate Co's quarry.—This quarry is located in T. 11 N., R. 10 E., within a quarter of a mile of that of the Chili Bar Slate Co., but on the north side of the river and west of the Placerville-Kelsey road. The principal opening was located about 600 feet north of the river, at an elevation of 150 feet above its bank. A tramway led down to the dressing yard, which was situated at the river bank.

The cleavage of the slates in the large opening strikes about N. 30° W. and has an almost vertical dip. No slate has been quarried here since 1897. A large stock of trimmed slates is still piled in the dressing yard, and many of these have already discolored badly.

Transportation and market.—The slates of Eldorado County have practically no competition on or near the Pacific coast, and the Eureka quarry has recently placed large shipments in Hawaii and Guam. Until recently the principal problem has been the transportation of the slates from the quarry to the railroad. This was formerly done by wagon hauling over a 6-mile stretch of very hilly road. In 1905, however, the Eureka Slate Co. installed an aerial tramway system from its quarry to a point near Placerville. This tramway is an engineering feat of no mean order, the crossing of the South Fork of American River being the principal difficulty encountered.

MERCED COUNTY.

A slate deposit was discovered in 1912 about 11 miles east of Planada, probably the Mariposa slate and of Jurassic age.[1] It is reported as 1,500 feet in width at the surface, 3 miles in length, and 300 feet in vertical thickness. The California Slate Co., of Planada, has commenced to develop the property. A specimen of the slate examined by the writer yields these results:

This slate is of dark bluish-gray color, with a somewhat lustrous, very finely granular surface with minute striations along the grain. Its fissility is good. It is very sonorous, indicating a high degree of metamorphism, does not effervesce with cold dilute hydrochloric acid nor show any carbonate in thin section, indicating durability of color. It is graphitic and contains many bronze-colored magnetic particles. Magnetite is not certainly present.

Under the microscope it shows a matrix of muscovite (sericite) very even in the grain direction with brilliant aggregate polarization, also conspicuous lenses with a nucleus of black mica (biotite). The biotite scales lie mostly parallel to the grain direction and the lenses, partly biotite and partly quartz, are elongated in the grain direction, but the biotite nucleus is crossed by parallel bands of dark inclusions that lie in the cleavage direction. It also contains many bronze-colored metallic particles and minute lenses of a highly magnetic mineral, presumably pyrrhotite (magnetic pyrites). The chief constituents of this slate, named in descending order of abundance, appear to be muscovite, quartz, biotite, kaolin, graphite, and pyrrhotite. Magnetite and rutile are not certainly present.

This is a mica slate of sedimentary origin, free from carbonate, with good cleavage. It should discolor but little if at all, but its content of magnetic particles makes it unsuitable for electric uses.

COLORADO.

The Colorado Slate Co. opened a quarry in 1910 in a deposit of black slate at Marble, in Gunnison County. The age of these slates is probably Ordovician. A specimen from this quarry examined by the writer yielded these results:

The slate has an extremely dark bluish-gray color. To the unaided eye its texture is fine, with a slightly uneven lusterless cleavage surface. It contains carbonaceous matter and extremely little magnetite. The sawn edge shows some pyrite. It effervesces with cold dilute hydrochloric acid, is sonorous, and has medium fissility.

Under the microscope it shows a matrix of muscovite (sericite) with feeble aggregate polarization. The cleavage is rendered uneven by alternating beds of fine and coarse particles, which are parallel to the cleavage. Carbonate is very abundant and helps to obscure the aggregate polarization. Pyrite is plentiful in spherules and irregular particles up to 0.16 millimeter across. Opaque carbonaceous matter also abounds, and there are several forms of organic origin. Rutile needles are very scarce or absent. Quartz grains measure up to 0.03 millimeter across.

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[1] See Turner, H. W., and Ransome, F. L., U. S. Geol. Survey Geol. Atlas, Sonora folio (No. 41), p. 2, 1897.

The constituents of this slate, named in descending order of abundance, appear to be muscovite, carbonate, quartz, carbon, kaolin, pyrite, chlorite, and rutile (?).

As shown by the defective aggregate polarization and confirmed by the scarcity of slate needles, this is an incompletely formed mica slate and it also belongs to the fading series. Its strength should be tested.

GEORGIA.

Roofing slates have been quarried in Bartow and Polk counties, in the northeastern part of Georgia.

BARTOW COUNTY.

Bolivar.—The Georgia Green Slate Co., of Fairmount, Ga., in 1910, opened a quarry in the northern part of Bartow County about 15 miles north-northeast of Cartersville and 3 miles northeast of Pinelog village, near Bolivar station of the Louisville & Nashville Railroad. The geologic age of the slate is as yet undetermined. It may be Cambrian.

The quarry lies in a hollow trending N. 60° W. along the south foot of a ridge about half a mile from the railroad. The opening is 175 by 50 to 100 feet in width, and in June, 1912, was idle and full of water. On the N. 60° W. side slate was exposed for 40 feet above the water and on the S. 60° E. side for 25 feet. As the hollow is narrow and the quarry was opened in the brook bed or close to it, the excavation soon fills.

The cleavage foliation strikes N. 30° E. and dips 5°-25° S. 60° E. The cleavage faces in the "top" are very limonitic and the region is thickly covered with rusty residual clays. The exact course of bedding could not be made out, but blocks on the dumps and the finished slates show ribbons intersecting the cleavage at 20°. Joints strike N. 63° E. and form a heading 15 feet wide at one end of the quarry, dipping 65° N. 27° W. Some of the slates show close joints filled with chlorite dislocating the ribbon but not affecting the cleavage. (See p. 39.)

The slate is of light blue-greenish gray color with some dark bluish-green ribbons, streaks, and lenses. It has a smooth to roughish, slightly lustrous surface, shows a little pyrite on the sawn edge, and contains extremely little magnetite. It effervesces slightly with acid test, is rather sonorous, and has a fair grade of fissility. The ribbons are somewhat calcareous.

Under the microscope it shows a matrix of muscovite (sericite) with marked aggregate polarization and a fine and regular cleavage, also abundant rutile needles. It contains a little carbonate in fine particles or rhombs and a little pyrite in spherules and irregular grains. There are lenses of chlorite up to 0.34 by 0.009 millimeter. The chlorite scales measure as much as 0.009 millimeter and the quartz grains 0.047 millimeter.

The constituents, named in descending order of abundance, appear to be muscovite, quartz, chlorite, carbonate, pyrite, magnetite, and rutile.

This is a mica slate with a fair fissility and attractive color. Although the amount of carbonate is not so large as in the sea-green slate of Vermont (p. 140) it is probably sufficient to produce in time some discoloration. The slates about the quarry, exposed not over two years, show but slight discoloration.

The following analysis of slate from Bolivar by Dr. Edgar Everhart, chemist of the Geological Survey of Georgia, is here given for reference:

Analysis of slate from Bolivar, Bartow County, Ga.

Silica (SiO_2)	56.02
Titanium dioxide (TiO_2)	.74
Alumina (Al_2O_3)	21.61
Ferric oxide (Fe_2O_3)	1.36
Ferrous oxide (FeO)	5.97
Manganous oxide (MnO)	.05
Lime (CaO)	1.22
Magnesia (MgO)	2.96
Potash (K_2O)	2.83
Soda (Na_2O)	1.26
Water (H_2O)	.14
Phosphorus pentoxide (P_2O_5)	.02
Carbon dioxide (CO_2)	.91
Sulphur (S)	.35
Loss on ignition, less carbonic acid (CO)	4.76
	100.20
Less oxygen	.09
	99.11

POLK COUNTY.

Rockmart.—The Rockmart slate, which belongs to the Ordovician period, was described by Hayes[1] in 1902 in these words:

> The Rockmart formation is confined to the Cedartown and Rockmart areas, in the southern portion of the Rome quadrangle. As stated previously, these rocks are contemporaneous with the upper portion of the Chickamauga limestone north of the Coosa Valley. The formation consists chiefly of black slate, originally calcareous shales, but sufficiently altered for the development of slaty cleavage. In addition to the slate, which occupies the lower portion of the formation, it contains beds of highly ferruginous sandstone and some cherty limestone. It also contains coarse conglomerates, made up of limestone pebbles embedded in an earthy matrix. This upper portion of the formation was evidently deposited near the margin of the sea, where the supply of sediment was abundant and variable in character. * * *
>
> The formation in which the quarries are located, the Rockmart slate, extends across the border into the Rome quadrangle, but it is not certain that any workable slate will be found in this area. The formation is variable in composition, and to the north of Rockmart consists largely of unaltered clay shales with beds of ferruginous limestone and sandstone.
>
> The portion of the formation which now produces roofing slate was originally a fine-grained homogeneous clay shale. Under the influence of metamorphism, connected probably with the extensive faulting which the region has undergone, a very perfect slaty cleavage was developed, which generally obscures, and in some cases entirely obliterates, the original bedding. East of the quadrangle, along the Cartersville fault, the slate is generally wrinkled near the fault, so that it does not cleave readily,

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[1] Hayes, C. W., U. S. Geol. Survey Geol. Atlas, Rome folio (No. 78), 1902.

and at a considerable distance from the fault the cleavage is only imperfectly developed. Hence the best slate will be found within a comparatively narrow belt, from 1 to 5 miles from the fault.

East and southeast of the village of Rockmart, on Euharlee Creek, is an east-northeast ridge of slate rising 100 to 200 feet above the creek, or 900 feet above sea level. The prevalent strike of the beds is N. 20°-40° E. The limestone which underlies the slate occupies the valley on the northwest and crops out in contact with the slate at the disused easternmost quarry. The slate is covered in places with 20 to 30 feet of weathered slate and this is overlain by 5 to 10 feet of reddish clay. Within this weathered zone all transitions from a black mica slate to a bright-yellow ocher can be studied. In an early stage of decarbonization the slate consists of alternating ribbons of grayish slate from 0.02 to 0.2 inch thick and of a buff-colored material, and both are crossed diagonally by a pronounced slaty cleavage. In a later stage of alteration the little beds can still be traced by pale-yellow bands in the bright-yellow clay, which still splits most readily in the direction of the original cleavage. In the final stage the slate has passed into an almost homogeneous structureless yellow ocherous clay.

The most important economic consideration suggested by the stratigraphy is that as the slate is limited in depth by the underlying limestone and in places in height by the zone of residual ocher the actual thickness of workable slate can not be very considerable. It should be carefully determined at any point before commencing operations involving large expenditures.

The Rockmart Brick & Slate Co. is engaged in manufacturing shale brick out of the weathered slate with the possibility, when the supply of ocher fails, of quarrying the underlying fresh slate for roofing.

The slate has been extensively quarried for roofing on the southeast side of the ridge, but the quarries are now disused. Pritchard & Davis, however, in 1912, reopened a small quarry between the Hood and Southern Slates Co. quarries, in a small northwest-southeast ravine. The opening is 20 by 25 feet by 10 feet deep and the "top" consists of 2 feet of red clay and soil. The beds strike about N. 40° E. and dip 20°-25° S. 50° E. The ribbons are wide and in places extremely plicated, as explained on page 32 and shown in figure 1. The thickness between ribbons in the Rockmart quarries is generally reported as from 2 to 5 feet. The cleavage strikes with the bed but dips 40°-45° S. 50° E. Joints strike N. 10° E. and N. 75° W., dipping steeply or vertical, both sets being discontinuous and spaced 15 to 18 feet.

The slate is of very dark bluish-gray color and of slightly roughish, lusterless surface. It is sonorous and effervesces with acid test. The sawn face shows minute magnetite;

the powder shows very little magnetite but much carbon and effervesces very freely with acid test.

Under the microscope aggregate polarization is somewhat obscured by carbonaceous matter. The general texture is lenticular and somewhat coarse, the quartz grains measuring up to 0.047 millimeter. Small beds down to 0.12 millimeter thick (in the slates of fig. 1 to 0.1 inch), with quartz grains to 0.09 millimeter and much carbonate, intersect the cleavage at 14°. The matrix contains much fine carbon, much carbonate, chlorite scales interleaved with muscovite, abundant spherules and grains of pyrite, and rutile needles. The section parallel to cleavage is crowded with carbonate.

The constituents, named in descending order of abundance, appear to be muscovite, quartz (detrital), carbonate, carbon, chlorite, kaolin, pyrite, magnetite, rutile, and plagioclase (detrital).

This is a mica slate of the fading series, although some obtained from a tunnel at one of the quarries is reported to have kept its color for many years. Its fissility is fair.

MAINE.

The slate region of Maine lies about in the center of the State, in the southern part of Piscataquis County, south and southeast of Moosehead Lake and east and west of Sebec Lake, in the towns of Monson, Blanchard, and Brownville. (See map, fig. 5.) Commercial slate occurs also in the town of Forks, Somerset County.

Geologic relations.—The slate occurs in a belt consisting largely of slaty rocks, represented by Hitchcock as 15 to 20 miles wide and extending from Kennebec River, between Bingham and Dead rivers, northeastward to the sources of Mattawamkeag River. The rocks are probably of early Paleozoic age.[1] The portion of this belt now yielding commercial slate lies south of the central granitic area of the State. The general structure of this belt is unknown. At North Blanchard, on the west, the strike of the bedding is N. 25°–39° E. and the dip 80° ESE. Near Blanchard and Piscataquis River the strike is N. 55°–62° E., and the dip, 40 feet below the surface, is south-southeast at about 80°; but at the top, owing either to the glacier, which moved here S. 20°–40° E., or else to the beginning of an anticline, the dip curves to the north-northwest. Within 1½ miles southwest of Monson the strike is N. 60° E. and the dip 90°. A mile south the strike is N. 63° E. and the dip still 90°. At Monson the strike is N. 47°–54° E. and the dip 80° SE.; but at Brownville, 20 miles east of Monson, the strike is N. 78° E. and the dip 75° NNW. As the grain is horizontal at Brownville and at points 3½ miles west-southwest and 1½ miles southwest of Monson, a nearly vertical pitch may be assumed for the folds, but it is singular that the jointing in the quartzite beds should not furnish any clue to this pitch.

Monson.—In 1912 three companies were operating quarries in the township of Monson. The Monson Maine Slate Co. was operating two quarries east-southeast of its Pond quarry; the Maine Slate Co. of Monson its Mathews quarry, about 3½ miles west northwest of the village; and the Portland-Monson Slate Co. four narrow openings about a mile south of the village.

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[1] See Hitchcock, C. H., The geology of northern New England, 1886; also his Preliminary report on the natural history and geology of Maine, including geologic map of northern Maine, pt. 1, pp. 316, 319, 1861, and Second Ann. Rept., pt. 2, pp. 280, 282, 360, 1862.

At the Monson Pond quarry the following series is exposed: Fifteen beds of slate, measuring altogether from 79 feet to 93 feet 6 inches, alternating with fifteen beds of dark-gray or black quartzite ("hards"), measuring altogether from 48 feet 5 inches to 49 feet 5 inches, both slate and quartzite aggregating from about 127 to about 142 feet. The deposit has been prospected for 200 feet farther southeast, but the slate beds range only from 4 inches to 2 feet in thickness and the quartzite beds vary considerably. The entire thickness explored here thus measures from 327 to 342 feet, and in that thickness there are no indications of duplication. This quartzite is usually very fine grained and under the microscope proves to be biotitic and pyritiferous, with a little magnetite and muscovite and a few grains of zircon. In order to convey an idea of the great irregularity of the interbedding which marks the entire belt the following measurements of the Pond quarry section at the north edge of the quarry are given.

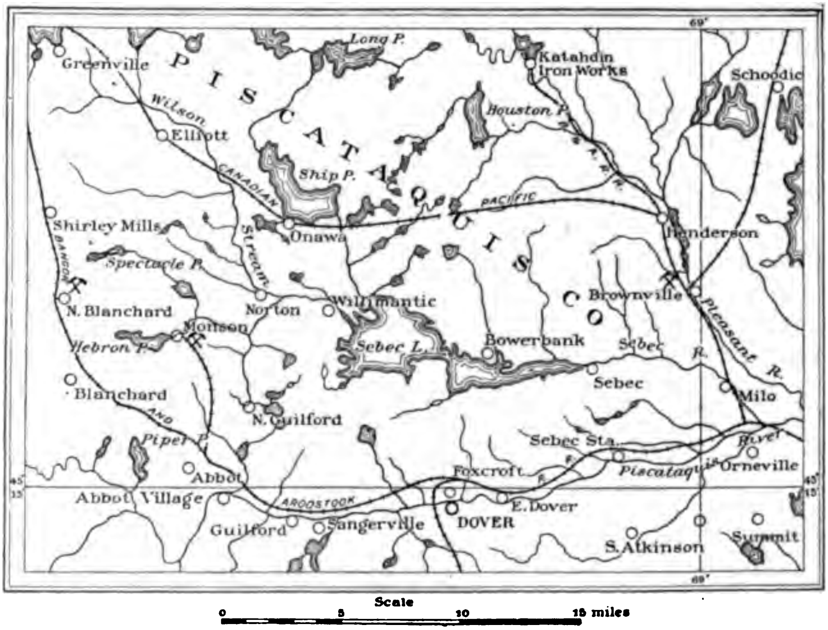

FIGURE 5.—Map of slate region in Maine. From post-route map. The chief quarrying centers are shown by crossed hammers.

Section at Monson Pond quarry, Monson, Maine.

[Furnished by the courtesy of Mr. F. H. Crane, superintendent.]

	Ft.	in.
Slate	7–18	0
Quartzite		6
Slate	1	8
Quartzite		2–8
Slate	1	10
Quartzite		8
Slate	2	0
Quartzite		3
Slate	4	0
Quartzite	1	6
Slate	4	0
Quartzite		8
Slate	4	0
Quartzite		6
Slate	15–18	0
Quartzite	4	0
Slate	5	0
Quartzite	1	4
Slate	7–8	0
Quartzite	4	0
Slate	3	0
Quartzite	1	2–4
Slate	3	0
Quartzite		8–12
Slate	[illegible]	0
Quartzite	20	0
Slate	7	0
Quartzite	2	0
Slate	6	0
Quartzite	11	0

Total slate, 79–93 feet 6 inches.

Total quartzite, 48 feet 5 inches to 49 feet 5 inches.

There is in places a transition from the quartzite to the slate, a quartzitic slate intervening. In the above section such beds are classified as quartzite.

The Pond quarry, now abandoned, measures about 500 feet along the strike and nearly 100 feet across at the top, and from 250 to 400 feet in depth. The beds strike N. 47° E. and dip 78°–80° SE., without any indication of turning, and the cleavage strikes N. 45° E. and dips 90°, thus intersecting the bedding at a very acute angle. The grain strikes N. 45°–50° W. and dips 90°. The slate is traversed at intervals by horizontal joints, which are more numerous in the quartzite—in places from 1 to 4 feet apart. The quartzite also has joints, striking N. 65° W. and dipping 25° N. 65° E., many of which are veined with quartz. There are also vertical diagonal joints striking about northwest and thus parallel to the grain. The northeast half of the quarry is much broken up by diagonal jointing and faulting, but in the southwest half conditions are more normal, although veining is there more common. The difference between the jointing of the quartzite and the slate results from the difference in their rigidity. Their behavior under the same stress must needs have been very dissimilar. Some of the quartz veins traversing the slate contain biotite, chlorite, and a little calcite. The surface of the formation is glaciated and covered with 5 to 10 feet of glacial clay and pebbles.

In 1909 a later and much longer opening next to the Pond quarry, on the east-southeast, had a length of 200 feet of its southern wall fall in, and the cost of removing the débris is reported to have been very great. It is difficult to see how such accidents can be avoided except by leaving supporting masses of unworked slate at short intervals. The horizontal close jointing of the quartzite greatly facilitates such falls.

The slate itself is very dark-bluish gray, but at the glaciated surface some of the beds have in bright sunlight a very slightly purplish hue. The fifth bed from the north edge is slightly brownish. To the unaided eye both texture and surface are fine, but the latter is almost lusterless. It is slightly graphitic and has very little magnetite. The sawn edge shows a little pyrite. No effervescence in cold dilute hydrochloric acid. It is very sonorous.

Under the microscope this slate shows a matrix of muscovite (sericite) with a brilliant aggregate polarization, but there is considerable irregularity in the size of the particles. Quartz fragments measure up to 0.017 by 0.008 millimeter. Some quartz lenses measure 0.094 by 0.047 millimeter. There are to each square millimeter about 100 scales of chlorite (interleaved with muscovite, rarely with biotite) measuring up to 0.047 by 0.03 millimeter and lying transverse to the cleavage; also about 18 scales of biotite to each square millimeter measuring up to 0.086 by 0.02 millimeter, lying both across and with the cleavage, and longish crystals and lenses of pyrite with their long axes parallel to the grain, numbering about 60 to the square millimeter and measuring up to 0.075 by 0.028 millimeter. These crystals are mostly distorted cubes, but mingled with them are probably some distorted octahedra of magnetite. Scattered throughout is dark-gray carbonaceous or graphitic matter in extremely minute particles, to which and to the biotite the slate owes its blackness. Finally, a few delicate rutile prisms, 0.001 millimeter long, some specks of hematite, and a few tourmaline prisms up to 0.036 by 0.004 millimeter. No carbonate detected.

The constituents of this slate, named in the order of decreasing abundance, appear to be muscovite, quartz, chlorite, biotite, pyrite, carbonaceous or graphitic matter, magnetite, rutile, and apatite.

The only available chemical analysis of this slate is that by L. M. Norton,[1] which shows 56.42 per cent of SiO_2, 24.14 per cent of Al_2O_3, and 0.52 per cent of CaO. This small percentage of lime, taken in connection with the occurrence of a little calcite in the quartz veins, points to the presence of an insignificant amount of carbonate, which the microscope fails to detect. But a little of this lime belongs to the apatite. The specific gravity is given by Bayley as 2.851. Tests of the crushing weight and strength made at the Massachusetts Institute of Technology show that a cubic inch of this slate yields to the pressure of 30,425 pounds when applied at right angles to the cleavage, and that a slab 12 by 6 by 1 inches, supported on knife edges 10 inches apart, breaks under a stress of 3,950 to 4,000 pounds applied at the center, with a steel rod, five-sixteenths inch in diameter, placed between the slate and the pressure block. This gives a modulus of rupture of 9,937 pounds to the square inch.

This slate is split to seven thirty-seconds of an inch for roofing. It is also used for electric purposes, register borders, blackboards, refrigerator shelves, etc.

At the Mathews quarry (Maine Slate Co. of Monson), opened in 1903, the thickest slate bed measures about 8 feet. The percentages of quartzite and slate are about 53.3 and 46.6. The strike of bedding and cleavage, taken 175 feet below the surface, is N. 62° E. and the dip 85° S. 28° E. There are two openings, the larger of which measures about 100 feet along the strike, 75 feet across it, and 180 feet in depth. On the north side of the east-northeast end is a tunnel extending 100 feet along the beds and 15 feet in width. Opposite to it on the west-northwest side is another of the same width, 55 fe in length and 40 feet high. In such tunnels in nearly vertical slat reliance is placed on lateral compression contracting the walls suff ciently to make a keystone of the roof. The grain dips 5° N. 62° so that the slate has to be sawn in a northwest-southeast vertic direction and "sculped" horizontally. There are vertical dip joint horizontal joints, and one diagonal joint. The product of this quarr is used for roofing.

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[1] See Bayley, W. S., U. S. Geol. Survey Bull. 150, p. 313, 1898, and Twentieth Ann. Rept., pt. 6 (continued), p. 394, 1899.

The slate is very dark bluish gray; to the unaided eye it has a finer texture and fin cleavage surface than that of the Monson Pond quarry, and also more luster. It slightly graphitic, has very little magnetite, but the sawn edges show considerab pyrite. It does not effervesce with cold dilute hydrochloric acid and is very sonorou

Under the microscope this slate shows a matrix of muscovite (sericite), with a ve brilliant aggregate polarization. There are lenses of biotite and quartz, or of quar with a nucleus of pyrite, measuring up to 0.565 by 0.14 millimeter, rarely 1 by 0.07 Quartz fragments, unusually abundant in sections parallel to cleavage, measure to 0.064 millimeter; biotite scales, about 63 to each square millimeter, measuring to 0.13 by 0.028 millimeter, lie across as well as in the cleavage. A little less abunda than these are scales of chlorite interleaved with muscovite, lying across the cleavag and measuring up to 0.13 by 2 millimeters. There are also about 1,160 lenses of pyri to each square millimeter, with their long axes in the cleavage, and measuring fro 0.002 to 0.094 millimeter in length, and up to 0.047 millimeter in width and breadt This number probably includes a few crystals of magnetite. Some of these lenses a surrounded by secondary muscovite. Generally distributed is a dark grayish or blac material, probably graphitic, to which the slate owes its blackness. Tourmalin prisms up to 0.047 by 0.009 millimeter. No carbonate was detected.

The relative abundance of these minerals appears to be, in descending order, musco vite, quartz, biotite, chlorite, pyrite, graphite, and magnetite.

The quarries of the Portland-Monson Slate Co., of 25 Centra Wharf, Portland, are about a mile south of Monson village and 1,60 feet west of the railroad. (See Pl. XXVI, *A*.) The largest opening measures 225 feet along the bed, 18 feet across it, and 180 feet in depth; another is 90 feet long and of the same width and depth; and two others are 75 feet long, 18 feet wide, and 60 and 40 feet deep, respectively. The slate surface is glaciated and covered with 10 feet of gravel. The strike of the quartzite and the cleavage of the slate are both N. 63° E., the dip 90°, and the grain vertical and at right angles to the cleavage.

A channeler is used on horizontal joints for vertical cuts along and across the cleavage to obtain working faces. In order to avoid the falling in of the lateral walls, steel I beams 20 inches in height are used as braces in groups of three or four, set 2 feet into the wall on either side and inclosed in concrete. These reinforced braces measure about 5 feet square and are placed 30 feet apart and in alternate superposition. A supporting mass of slate, which can be tunneled later, is left every 60 feet.

The slate of these quarries is very dark bluish gray and has a lusterless roughish cleavage surface with marked grain. Its fissility is good. Pyrite very minute and sparse. The slate does not effervesce with acid test. The powdered slate effervesces slightly, is very graphitic, and shows some magnetite.

Under the microscope the matrix has a brilliant aggregate polarization, an even (not lenticular) texture, but with some passages of coarser quartz grains (up to 0.06 millimeter). Meandering incipient plications cross the cleavage and bedding at right angles in the grain direction. Quartz (detrital) is generally very minute, not over 0.04 and mostly under 0.03 millimeter; it appears to be less plentiful than in the slate of Northfield, Vt. (See p. 122.) Chlorite scales plentiful and larger than quartz grains. No rutile was detected, or carbonate, although test with powdered slate shows its presence. Rare tourmaline prisms. Sparse biotite scales, not over 0.06 millimeter across, number about 14 per square millimeter. Conspicuous magnetite crystals or lenses (with a few particles of pyrite), 0.047–0.094 millimeter long and 0.009–0.03 millimeter wide, number about 31 per square millimeter. The constituents, named in descending order of abundance, are muscovite, quartz, chlorite, magnetite, biotite, pyrite, carbonate, and tourmaline.

The slate is a mica slate of the unfading series and is used entirely for millstock, mostly for electric purposes. The president of the company states that electrical tests of this slate show that its insulating qualities are not affected by any magnetite content it may have. The amount of magnetite may also vary in different beds.

West Monson.—At the quarry of the Monson Consolidated Slate Co. is exposed a bed of black slate 9 feet thick, with a bed of quartzite 15 feet thick on its north side and small alternating beds of quartzite and slate on its south side, the whole series measuring perhaps 50 feet. The quarry in 1904 measured 300 feet along the strike, 15 feet across it, and 160 feet in depth. The walls are supported by three pillars of slate. Bedding and cleavage both strike N. 60° E. and dip 90°. There are vertical dip joints striking N. 15° W.; also horizontal joints, to which the grain is parallel. About 15 feet of till lies on the edges of the glaciated slate. As only one bed of slate is worked, the percentage of waste at this quarry is very small.

The slate is a very dark gray. To the unaided eye its texture and cleavage surface are very fine. It has more luster than the slate of the Pond quarry, but not so much as that of the Mathews quarry. It is slightly graphitic, has no magnetite, but shows pyrite on sawn edges; does not effervesce with cold dilute hydrochloric acid, and is very sonorous.

Under the microscope this slate shows a matrix of muscovite (sericite) with a brilliant aggregate polarization. There are a few lenses of quartz and biotite, measuring from 0.107 to 0.13 by 0.034 millimeter, some lying in the cleavage, others in the direction of the grain. The quartz fragments measure up to 0.02 by 0.012 millimeter. There are about 17 biotite scales to each square millimeter, measuring up to 0.08 by 0.02 millimeter; also about 248 chlorite scales, the larger ones measuring from 0.047 by 0.02 to 0.085 by 0.03 millimeter, with their longer axes and laminæ usually parallel to the cleavage and across the grain; and finally, 30 to 88 lenses and crystals of pyrite to each square millimeter, measuring, in sections across the cleavage, up to 0.066 by 0.02 millimeter, with their longer axes parallel to the cleavage, and the usual finely disseminated carbonaceous matter; also tourmaline prisms up to 0.007 by 0.008 millimeter. No carbonate was detected.

The probable relative abundance of these constituents, in descending order, is muscovite, quartz, chlorite, pyrite, biotite, and carbonaceous matter or graphite. Merriman's tests of this slate are given on page 183.

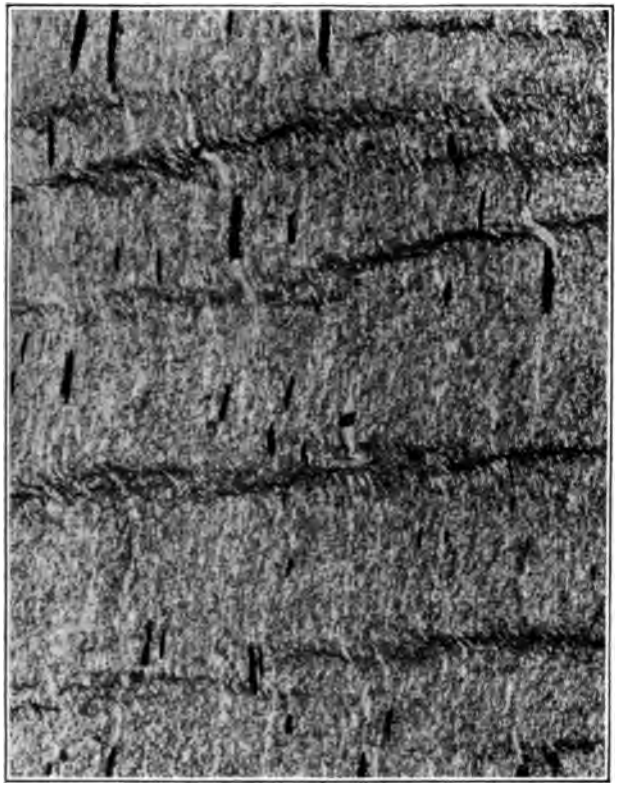
In 1904 the slate was used both for roofing and for electric purposes. The quarry was idle in 1912.

North Blanchard.—There are two quarries at North Blanchard which were both operated in 1904 by the Lowell Slate Co. At the State of Maine or Blanchard quarry 50 feet of slate and quartzite, 10 beds of each, in alternation, are exposed, and 200 or 300 feet more have been prospected east of the quarry. The quarry measures between 250 and 300 feet along the strike, 40 to 50 feet across it, and 200 feet in depth. Both bedding and cleavage strike N. 25° E. and dip 80° ESE. The slate has vertical dip joints striking N. 70° W. and diagonal ones striking N. 40° W. and dipping 32° SSW. There are also joints confined to the quartzite, dipping 65°–70° SSW. and also 65°–70° NNE. The grain strikes N. 65° W. and dips 90°, almost like the dip joints. The surface of the deposit is glaciated and covered with 10 feet of till. Some of the quartzite surfaces show faint traces of marine life. At the Moosehead quarry, which lies half a mile southwest or south-southwest of the last, more than 65 feet of slate and quartzite are exposed. The thickest beds of slate measure 4 and 7 feet. The quarry measures about 500 feet along the strike, 50 feet across it, and 125 feet in depth. Bedding and cleavage both strike about N. 37° E. and dip 80° ESE. Dip joints strike N. 55° W. and dip 90°. The quartzite on the west side of the quarry is broken up by undulating horizontal joints from 1 to 4 feet apart. The grain corresponds to the dip joints.

The slate from these quarries is a very dark gray. To the unaided eye the texture and cleavage surface are fine, but the latter is only slightly lustrous. The slate contains a little carbonaceous or graphitic matter and no magnetite, but the sawn edges show pyrite. No effervescence in cold dilute hydrochloric acid. It is very sonorous and very fissile.

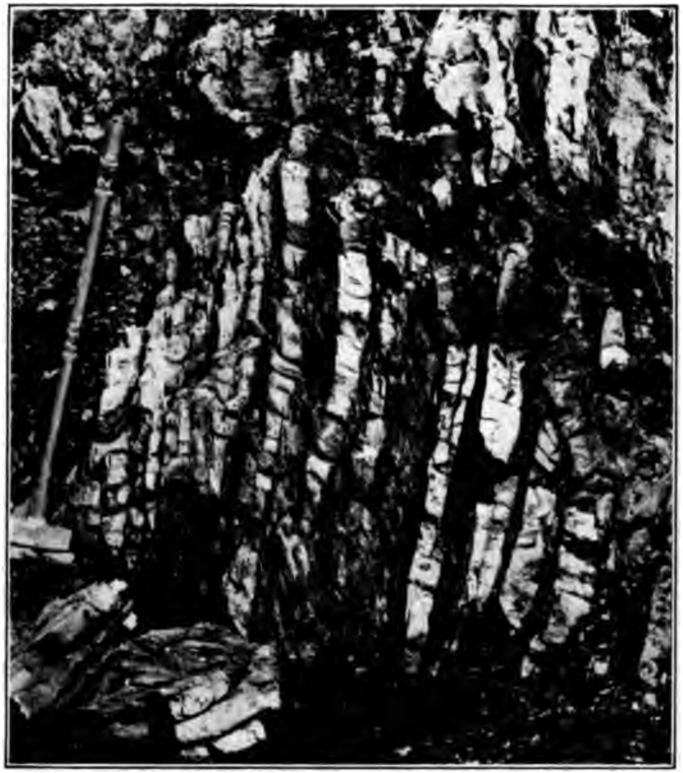
Under the microscope this slate shows a matrix of muscovite (sericite), with brilliant aggregate polarization. A thin section parallel to the cleavage shows muscovite scales sufficiently numerous and parallel to produce a slight aggregate polarization. This may be due to an unusually pronounced grain. The quartz fragments occasionally measure 0.028 millimeter and are not abundant. There are about 380 scales of chlorite, interleaved with muscovite or biotite, to each square millimeter, with their laminæ across the cleavage and measuring up to 0.066 by 0.028 millimeter; also, about seven biotite scales to each square millimeter, measuring up to 0.085 by 0.047 millimeter, many of them bordered by secondary quartz or muscovite in the direction of the slaty cleavage, but with their laminæ transverse to it. There are about 850 lenses of pyrite to each square millimeter, measuring from 0.004 to 0.03 millimeter in length and up to 0.01 millimeter in width; much dark-gray carbonaceous or graphitic matter in exceedingly fine particles; tourmaline prisms up to 0.07 by 0.009 millimeter are plentiful. No carbonate or slate needles found. The chief constituents, named in descending order of abundance, appear to be muscovite, chlorite, quartz, pyrite, graphite, and biotite.

This slate was used in 1904 for roofing and mill stock, including electric appliances. In 1912 the quarries were idle.



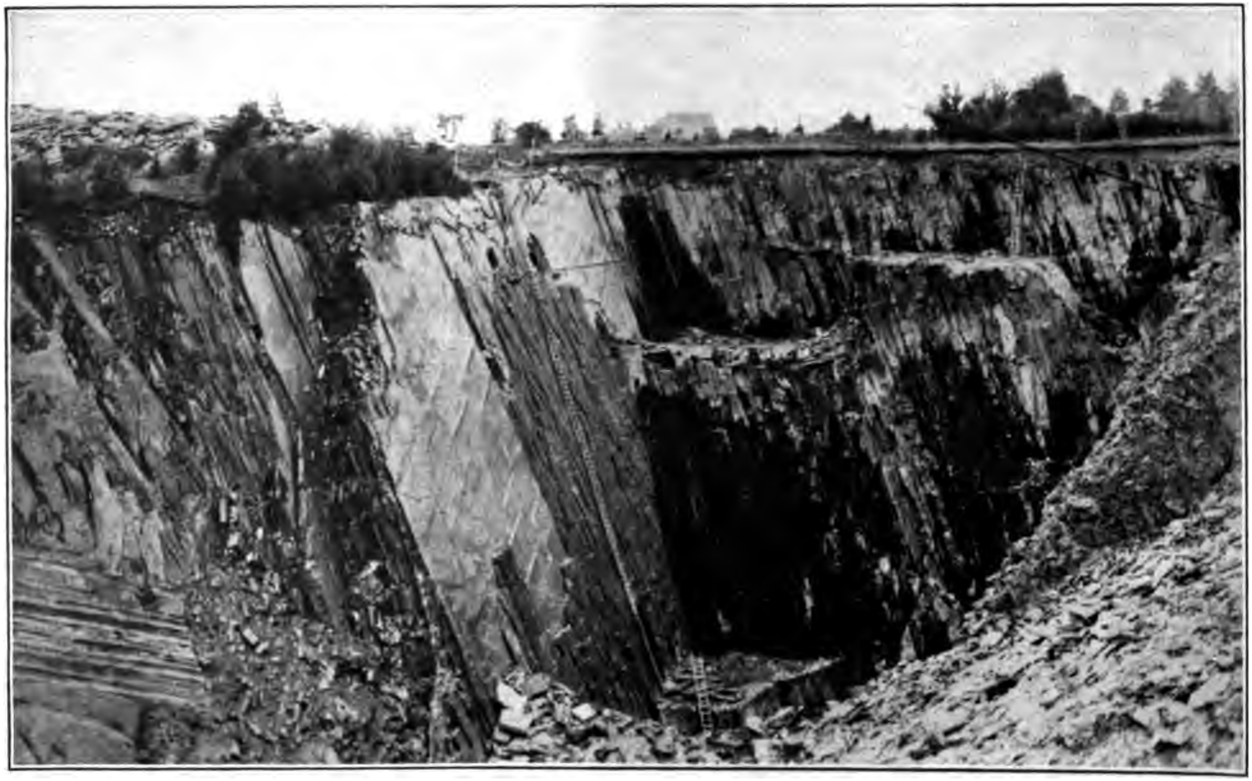
A. THIN SECTION OF BLACK ROOFING SLATE FROM MERRILL QUARRY, BROWNVILLE, ME.

Showing fine matrix of muscovite (sericite) with distorted octahedra of magnetite and (exceptionally for this quarry) a secondary plication resulting in slip cleavage. Lenses of chlorite and muscovite or of quartz and muscovite or of muscovite alone about some of the magnetite crystals. Enlarged about 50 diameters.



B. CLEAVAGE BANDING IN SHALES PARTLY ALTERED TO SCHIST, RUPERT, VT., NEAR THE HEBRON (N. Y.) LINE.

Showing alternate bands of finely cleft and uncleft rock, dipping 80° across the bedding foliation, which is visible at several points and dips at a low angle. Slip cleavage. The lower block in the foreground has three uncleft and two cleft bands. Sledge handle is 30 inches long.



MERRILL SLATE QUARRY, BROWNVILLE, ME.

Looking S. 60° W. The end wall, working face, has 42 beds of slate alternating with quartzite. The left wall is quartzite that is diagonally jointed.

Brownville.—The Old Merrill quarry at Brownville, operated in 1904 by the Merrill Brownville Slate Co., lies less than a mile about northeast of the station. (See Pl. XII.) Here are exposed 42 beds of slate, alternating with as many of quartzite, the whole measuring 165 feet in thickness. The slate beds range from 6 inches to 6 feet, and the quartzite beds from 6 inches to 5 feet 6 inches. Any quartzitic slate is considered quartzite in these calculations.[1]

At the Hughes quarry, owned by the same company, situated a mile northwest of the Merrill, there are 28 beds of slate alternating with 28 of quartzite, measuring in all 161 feet 6 inches. The slate beds range from 1 to 9 feet and the quartzite from 4 inches to 20 feet in thickness. There is no evidence of duplication in this series of beds. Some of the quartzite is grayish and medium grained. Under the microscope it proves to be chloritic, pyritiferous, and slightly biotitic, with rare grains of zircon.

The Merrill quarry measures about 450 feet along the strike, between 165 and 200 feet across it, and 250 feet in depth. The bedding strikes N. 78° E., and dips 75° NNW.; the cleavage strikes N. 68° E. and dips 70° NNW. Dip joints strike N. 20° E. and dip 82° WNW.; diagonal joints strike N. 60° W. and dip 90°. There are also horizontal joints, to which the grain is parallel. Quartz veins are not conspicuous, but there are some quartz lenses from 2 to 3 feet in diameter. These veins contain a little biotite. The south wall of the quarry (see Pl. XII), which is formed by a quartzite bed, is divided into rhombic blocks about 10 feet in their longer diameter, owing to the intersection of joints dipping 25° W. and 30° E. The surface of this bed has also what resembles a coarse ripple marking but is probably a minor effect of the rhombic jointing.

The slate is a very dark gray. To the unaided eye it has a very fine texture and a very smooth cleavage surface, with a very bright luster. It is slightly graphitic. When powdered, it yields considerable magnetite to the magnet. The sawn edges show lenses of pyrite a millimeter and less in length. Some of the cleavage and other surfaces on the dumps show a very dark purplish coating. There is no effervescence in cold dilute hydrochloric acid nor any discoloration whatever. It is very sonorous and fissile.

Under the microscope it shows a very fine grained matrix of muscovite (sericite), with a very brilliant aggregate polarization. It contains much quartz in fragments up to 0.076 by 0.02 millimeter; about five biotite plates to each square millimeter, measuring up to 0.076 by 0.03 millimeter, lying across the slaty cleavage. Many of these plates form the nuclei of quartz lenses which measure up to 0.4 by 0.03 millimeter. But the most conspicuous feature, next to the brilliant matrix, is the abundance of magnetite in tabular crystals, probably distorted octahedra, lying parallel to the cleavage, from 29 to 49 to each square millimeter, and measuring from 0.009 to 0.17 millimeter in length and up to 0.04 millimeter in width. Some of these crystals are bordered by secondary quartz and muscovite or chlorite, on one or both sides, particularly wherever they happen to diverge from the cleavage directio These secondary minerals occupy spaces resulting from a movement of the crystal after the commencement of slaty cleavage. There are also, but in less abundanc lenses of pyrite, up to 0.75 millimeter long and 0.12 millimeter wide, consisting of nucleus of pyrite surrounded by secondary quartz or by this and biotite, these mineral forming the tapering part of the lens. There is also the usual abundance of dark-gra graphitic material in extremely fine particles. Not a few prisms of tourmaline occur up to 0.043 by 0.008 millimeter. No carbonate.

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[1] Measurements obtained through the courtesy of C. H. Dunning, superintendent.

Plate XI, *A*, will give some idea of the distribution of the magnetite crystals in thi slate, but the "false cleavage" of the specimen is not typical of the product of th Merrill quarry—indeed it is quite exceptional. The specimen was selected to illustrate "false cleavage" as well as the fineness of slaty cleavage. The principal constituents, named in descending order of abundance, appear to be muscovite, quartz, magnetite, pyrite, graphite, biotite, chlorite, tourmaline. This is a highly crystalline mica slate of the unfading series with a bright cleavage face.

W. O. Crosby found that the slate of the East Brownville Slate Co. had an average crushing strength of 29.270 pounds to the square inch, the weight being applied perpendicular to the cleavage, and that it required 3,550 pounds to break a slab 6 inches wide, 1 inch thick, and 11 inches long between supports, the load being applied at the middle. This would give a modulus of rupture of 9,762 pounds to the square inch. The results of Merriman's recent tests of slate from Brownville will be found on page 183.

The product of the Merrill quarry was used exclusively for roofing purposes; its magnetite is thought to prevent its use for electric appliances. However, a piece 6 by 4 inches by one-half inch makes no impression whatever on the magnetic needle, and the section photographed in Plate XI, *A*, came from that piece. The quarry was idle in 1912.

Forks, Somerset County.—A slate prospect opened in the town of Forks in 1890 was visited by the writer in 1905. This prospect is about 18 miles west of the North Blanchard quarries, in the southwest corner of the town of Forks, about 3 miles northeast of Caratunk and about a mile northwest of Pleasant Pond. It is on Holly Brook, on land owned by Lawrence Hill. The nearest railroad is the Somerset Railway extension at Mosquito Narrows, 6 miles distant.

The cleavage strikes N. 55° E. and dips from 90° to steep northwest and southeast, owing to minor folding. The bedding is probably not far different.

The slate is bluish black, of fine texture and cleavage surface, with a luster not so great as that of the slate at Brownville. It is graphitic, contains a very small amount of magnetite, has no argillaceous odor, does not effervesce in cold dilute hydrochloric acid, is sonorous, splits, and can be perforated readily. Neither the ledge nor the fragments, said to have been exposed 15 years, show discoloration.

Under the microscope the section shows a matrix of muscovite (sericite) with a brilliant aggregate polarization, proving it to be a mica slate. The cleavage is fine and regular. There are about 52 lenses of pyrite to each square millimeter, measuring (in transverse section) from 0.02 to 0.06 millimeter in length and 0.004 to 0.016 millimeter in width. In sections parallel to the cleavage these lenses have a very irregular outline and many of them are as broad as long. These lenses account for the limonitic staining on cleavage surfaces of water-soaked specimens. Quartz is abundant but minute. No carbonate was detected. A few tourmaline prisms up to 0.11 millimeter in length. Some scales of chlorite with interleaved muscovite measure up to 0.09 millimeter. There are rare zircon fragments and aggregations of rutile crystals.

The constituents of this slate, named in descending order of abundance, appear to be muscovite, quartz, chlorite, pyrite, and graphite, with accessory tourmaline, zircon, and rutile.

This slate of Pleasant Pond differs from the slates of Monson in having a lustrous and smooth surface, and from the slate at Brownville in having much less magnetite and a little less luster. It would prove suitable for roofing or mill stock.

Whether, like the other slates of this State, it is interbedded with quartzite at frequent intervals could not be determined.

The more important features of the slates of Maine as brought out in the above descriptions are set forth in tabular form opposite page 188.

MARYLAND.

The slate of Cardiff, in Harford County, Md., about 30 miles northeast of Baltimore, extends up into Pennsylvania and will be considered under the heading "York and Lancaster counties" (pp. 110–115). Slate occurs also in Montgomery and Frederick counties, about 40 miles west of Baltimore and 33 miles northwest of Washington, where it has been prospected and quarried to a small extent. (See fig. 6.)

Geologic relations.—For the geology of the region the reader is referred to the writings of Williams,[1] Keyes,[2] and Mathews.[3] Keyes's section passes through Sugarloaf Mountain and along the Baltimore & Ohio Railroad (Metropolitan branch) to the northern corner of the District of Columbia. Its important features are these: Sugarloaf Mountain is a mass of eastward-dipping Cambrian sandstone passing toward the east into and under a belt of slaty or schistose rocks (phyllites), which Williams described as containing sericite, chlorite, quartz, hematite, and tourmaline. The phyllite area is traversed in several places by Mesozoic diabase dikes, and east of it are contorted gneisses.

This slate belt, whatever may be its exact bounds, is well exposed at Ijamsville, on Bush Creek and the Baltimore & Ohio Railroad, in Frederick County, where it has a well-defined strike of N. 10° E. Between Ijamsville and a point 2½ miles south-southwest of that place it is at least 1½ miles wide, and reappears west of Hyattstown, 3½ miles farther south, in Montgomery County; and from that point its

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[1] Williams, G. H., The petrography and structure of the Piedmont Plateau in Maryland: Geol. Soc. America Bull., vol. 2, pp. 301–318, Pl. XII, 1891.

[2] Keyes, C. R., A geological section across the Piedmont Plateau in Maryland: Idem, pp. 319, 322, fig. 3.

[3] Mathews, E. B., On Ijamsville slate: Maryland Geol. Survey, vol. 2, pp. 231–232, Pl. XXX, 1898.

exposures and cleavage strike range from S. 20° W. to S. 37°
It thus passes between Sugarloaf Mountain and the village of Mou

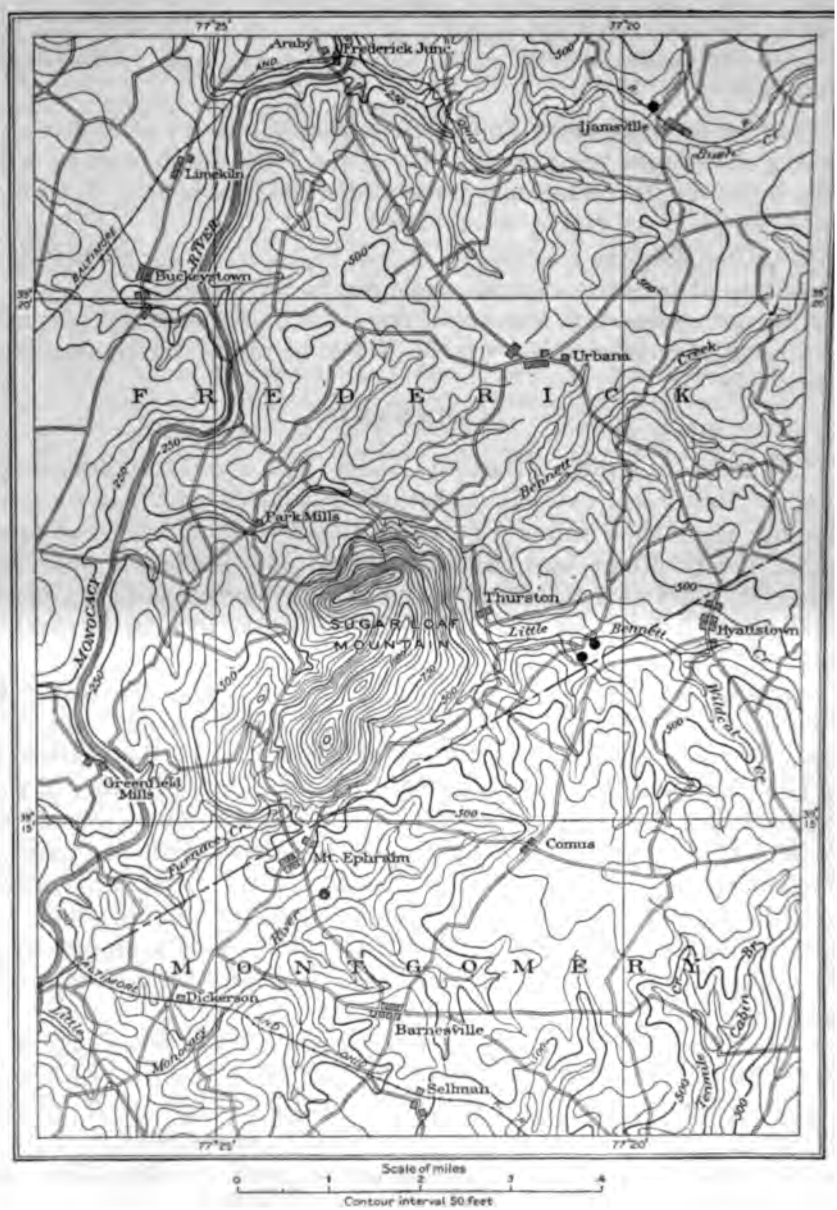

FIGURE 6.—Map of parts of Frederick and Montgomery counties, Md., showing (by dots) slate prospect and abandoned quarries.

Ephraim on the west and Hyattstown and Barnesville on the east
its minimum length and width being about 12 and 1½ miles respec

tively. Immediately east of this belt are chloritic schists and altered diabases.

E. B. Mathews [1] has recently concluded that some of the slates of Frederick County are of volcanic origin or contain material of such origin.

Ijamsville.—One-fourth mile west of Ijamsville station is an abandoned quarry in dark, slightly reddish purple slate.[2] The bedding, shown by light-green ribbons, strikes N. 10°–15° E. and dips 30°–40° W., but the cleavage strikes N. 40° E. and dips 50° SE. There are intermittent joints striking N. 15°–20° E., dipping 75° ESE., which have been parted a fourth of an inch, lined with quartz, and filled with calcite. Similar slate, but interbedded with light green, occurs also several hundred feet east and north of the station.

Thurston.—On Little Bennett Creek, about half a mile east-southeast of Thurston, in Frederick County, is another quarry (opening 70 by 50 feet) operated in 1885 but now abandoned. The slate is also dark purplish with light-green passages containing here and there a scaly bright-green mineral, pyrophyllite, which carries from 1 to 2 per cent of copper oxide. The bedding, indicated by coarsely plicated quartzose passages, appears to be about horizontal. A piece of this slate that is said to have been on a roof many years shows some lightening of the color, owing chiefly to the growth of lichens, but the change is only superficial. The cleavage strikes N. 20° E. and dips 60° E. There is a 2-foot quartz vein in the "top."

About 600 feet south-southwest of this quarry and half a mile southeast of Thurston is the quarry opened or reopened by the Bennett Creek Slate Co. about 1904, measuring 75 feet along the cleavage by 65 feet across it. In May, 1904, this quarry had a depth of 40 feet. The upper 25 feet is "top." The cleavage strikes N. 37° E. and dips 40° E., with green spots aligned in the same direction. Joints strike N. 30° E. and dip 40° W. The grain is almost at right angles to the cleavage.

The slate is dark purplish but has a bluer tinge than that of Ijamsville. To the unaided eye it has a slightly granular texture, a rather fine cleavage surface with distinct grain and a little luster. It contains no magnetite, does not effervesce with cold dilute hydrochloric acid, and is somewhat greasy to the touch. The sawn edges show light-green particles and more minute pyrite ones. The sonorousness is medium. Some of the slates on exposure develop dark spots, due to the oxidation of some mineral. The amount of quartz is so small that slabs half an inch thick may be easily sawn across the cleavage and the grain with a handsaw.

Under the microscope it shows brilliant aggregate polarization, but much irregularity in size of particles and very slight plications in the direction of the grain. The matrix of muscovite (sericite) contains abundant quartz fragments, measuring up to 0.094 millimeter. There are conspicuous scales of chlorite, often interleaved with muscovite lying transverse to the cleavage, measuring as much as 0.38 by 0.25 millimeter, or exceptionally 0.66 by 0.14 millimeter, and forming the centers of lenses o sericite or talc (?)[1] measuring up to 1.5 millimeters in length. There are also lense of sericite or talc (?)[1] measuring up to 0.56 by 0.09 millimeter with their long axes i the grain direction.

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[1] Maryland Geol. Survey, vol. 8, pp. 133-136, 356-357, 1900.

[2] Idem, vol. 2, pp. 231, 232, Pl. XXIV, fig. 2, 1898.

These scales and lenses number about 88 per square millimeter, of which abou 18 are chlorite. Multitudinous minute dots of bright-red hematite occur throughout the slate, and to these and the chlorite it owes its purplish color. Among thes dots are many particles of pyrite, some of which measure 0.038 millimeter. A few o these have passed into limonite. Slate needles (TiO_2) are somewhat plentiful. N carbonate. Tourmaline 0.076 by 0.009 millimeter. The important constituents o this slate, named in order of abundance, appear to be muscovite, chlorite, quartz talc, hematite, pyrite.

Its deficient sonorousness is not due to the absence of a micaceous matrix, but t the presence of a large amount of chlorite and to about 5 per cent of talc. It is slightly talcose mica slate.

Mount Ephraim.—About 4 miles southwest of the Bennett Creek quarries and a quarter of a mile south-southeast of the village o Mount Ephraim, in Montgomery County, east of the road to Barnesville and north of Little Monocacy River, on the property of Abraham Harris, a similar slate has been prospected. The cleavage strikes N. 30°-35° E. and dips 70° E. The bedding probably strikes N. 30° E.; the dip is uncertain.

The characteristics of the slates of Maryland are shown in the table facing page 188.

MINNESOTA.

By Edwin C. Eckel.

Deposits of roofing slate occur in northern Minnesota, a few miles west of Duluth. At present, however, all the quarries formerly opened here are abandoned, and the quality of the slate, as seen in specimens from the old dumps, is hardly such as to justify reopening.

The following reports and papers, while not economic in intention, contain data of interest on the distribution and character of the slates of Minnesota:

Hall, C. W., Keewatin area of eastern and central Minnesota: Geol. Soc. America, Bull., vol. 12, pp. 345-376, 1901.

Spurr, J. E., The stratigraphic position of the Thomson slates: Am. Jour. Sci., 3d ser., vol. 48, pp. 159-166, 1894.

Winchell, N. H., The geology of Carlton County: Minnesota Geol. Survey Final Repts., vol. 4, pp. 1-24, 1899.

——— The geology of the southern portion of St. Louis County: Idem, pp. 212-221.

——— The geology of the Carlton plate: Idem, pp. 550-565.

——— The geology of the Duluth plate: Idem, pp. 566-580.

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[1] Mathews (Maryland Geol. Survey, vol. 2, p. 232), following some determination by G. H. Williams, regarded these slates as containing talc. A chemical test made by George Steiger at the United States Geological Survey laboratory shows 0.27 per cent of SiO_2 soluble in 1-20 solution of Na_2SO_3 before ignition, and 1.09 per cent after ignition. F. W. Clarke, chief chemist, notes that the difference, 0.82 per cent, corresponds to a splitting off of SiO_2 from the talc if talc is present. It would be one-fourth of the SiO_2 in the talc and thus represent a percentage of 5.17 of talc. As the only other silicates in the slate are crystalline quartz, chlorite, muscovite (sericite), and tourmaline, this result is reliable. The combination of chlorite and sericite alone would be sufficient to account for the "talcose" touch of the slate.

NEVADA.

The discovery of slate in the Blue Mountains in Humboldt County, Nev., was reported to the Geological Survey in 1908. The deposit occurs about 21 miles northwest of Winnemucca and is said to be extensive.

This slate may belong to the Mariposa slate, of Jurassic age. Clarence King[1] described a slate of the region in these words:

> Over the Jurassic limestone on the northern points of the West Humboldt Range is a very heavy body of variable but generally argillaceous slate. The exposure on Humboldt Canyon is of over 2,000 feet and on the north side of the Humboldt valley the same slate group is exposed with even greater thickness.

On page 268 of the same work King correlates these Jurassic slates with similar rocks at Mariposa, Cal.[2]

Specimens reported as having been obtained from more or less weathered outcrops on the Gibraltar group of claims were examined with the following result:

> The slate is of dark bluish-gray color. To the unaided eye it has an extremely fine texture and a very smooth, slightly lustrous cleavage surface. It contains some carbonaceous or graphitic matter and, as shown by the magnet, a little magnetite. The sawn edges show neither pyrite nor magnetite. It does not effervesce with cold dilute hydrochloric acid. It is sonorous and has a very high grade of fissility. The cleavage face shows traces of "grain," but the slate breaks usually at angles of 50° to 70° and 30° to the apparent grain.
>
> Under the microscope this slate shows a matrix of muscovite (sericite) with well-defined aggregate polarization and is thus a mica slate. The cleavage is fine, although showing some minor irregularities in the size of particles. The quartz particles measure up to 0.06 millimeter in diameter; one plagioclase feldspar measured 0.04 millimeter. No pyrite was detected. The dark particles are nonmetallic and probably carbonaceous. Rather abundant scales of chlorite and of interleaved chlorite and muscovite measure up to 0.14 millimeter in length and to 0.05 millimeter in width. Rutile is very abundant both in single needles and more in net-shaped groups of twinned needles (sagenite) measuring 0.02 millimeter across. There is a little limonite proceeding possibly from the magnetite and due to incipient weathering. No carbonate could be found.
>
> Its constituents, in descending order of abundance, appear to be muscovite, quartz (detrital), chlorite, carbon (probably graphite), rutile, magnetite, and plagioclase (detrital).
>
> The fissility of this slate is equal to that of the slates of Pennsylvania, but its freedom from carbonate indicates that its color will prove more durable.

NEW JERSEY.

The slate belt of Lehigh and Northampton counties, Pa., is prolonged eastward into New Jersey, where roofing-slate quarries have been opened at several points, notably near Newton and Lafayette, in Sussex County.

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[1] King, Clarence, Systematic geology: U. S. Geol. Expl. 40th Par., vol. 1, p. 295, 1878.

[2] See Smith, J. P., Age of the auriferous slates of the Sierra Nevada: Geol. Soc. America Bull., vol. 5, pp. 243-258, 1894; also Turner, H. W., and Ransome, F. L., U. S. Geol. Survey Geol. Atlas, Sonora folio (No. 41), p. 2, 1897.

Lafayette.—The quarry of the Lafayette Slate Co., of Newtc
N. J., the only slate quarry in operation in this State in 1912,
about 2 miles N. 25° E. from Lafayette village and nearly 28 mil
northeast of the Delaware Water Gap. The opening measures abo
200 feet in a N. 20° W. direction by 85 feet across and 70 to 1
feet in depth. The "top" consists of 5 to 15 feet of weathered sla
and till. The beds (ribbons) strike N. 45° E. and dip 20°–30°
45° W. The cleavage strikes N. 70° E. and dips 20° S. 20° E. The
are two sets of joints. Those of one set strike N. 10°–45° E., d
70° S. 63° E., and are spaced 2 to 20 feet. Those of the other s
strike N. 30° W., dip 90°, and are spaced 5 to 40 feet. Owing
secondary motion the slate is more or less bent (not curved) at ea
ribbon. The weathered slate of the "top" is of light-brownish colc

The slate is very dark bluish gray. To the unaided eye it has a fine texture an
slightly roughish, lusterless cleavage surface. The sawn edge shows pyrite. It eff
vesces with acid test, and the ribbon still more. The powdered slate is very eff
vescent, carbonaceous, and but very slightly magnetitic. It has a high grade
fissility and is sonorous.

Under the microscope this slate shows a matrix of muscovite (sericite) with
aggregate polarization somewhat obscured by abundant carbonate, and with ve
elongate lenticular texture. Beds 0.75 millimeter thick cross the cleavage at 3
Quartz grains (detrital) up to 0.034 millimeter. Chlorite scales, some with interleav
muscovite, up to 0.08 millimeter, lie at right angles to the cleavage. Sparse pyr
spherules 0.004–0.012 millimeter across. Carbonaceous matter in short streaks p
allel to beds. In these beds the carbonate is coarser and the quartz up to 0.66 mil
meter. Rutile needles.

The constituents, named in descending order of abundance, appear to be mus
vite, quartz, carbonate, chlorite, carbon, kaolin, pyrite, magnetite, and rutile.

This is a mica slate of the fading series. It is reported as being harder than sla
of Bangor, Pa., and as preserving its color on the roof for at least 30 years.

It is supplied to the market in two qualities—No. 1, generally ve
slightly bent; No. 2, with one or two very obtuse bends, giving to ea
slate a zigzag outline in longitudinal section. When in full operatic
this quarry employs eight splitters.

There is an abandoned quarry about half a mile S. 70° W. fro
the quarry described above. The opening is triangular, about
feet on a side and about 90 feet deep. The beds strike N. 60°
and dip 20° N. 30° W.; the cleavage strikes N. 55° E. and dips 3
S. 35° E. Although the quarry has not been worked for many yea
the slate on the dumps, which cover several acres, is generally ve
dark, but a quarried cleavage face at the edge of the quarry is ligl
brownish gray.

NEW YORK.

GEOLOGIC RELATIONS.

The slates of Washington County, N. Y., are a continuation
those of Rutland County, Vt. The Lower Cambrian affords greeni
and purplish slat[illegible] Vermont described on page 13

which were once extensively quarried at Middle Granville and Jamesville. Overlying the Lower Cambrian, in isolated lenticular synclinal areas or in long, ramifying masses of complex structure, are Ordovician grits and black, red, and green shales; and these red and green shales pass here and there into roofing slates.[1] (See Pl. XX.)

Although the Lower Cambrian greenish and purplish slates are at present quarried almost exclusively on the Vermont side of the boundary, the red and green slates attain their best development on the New York side, particularly in the towns of Granville, Whitehall, and Hampton. The structural relations of the two slate-bearing formations on the New York side are shown in Sections I, II, VII of Plate XXII and are explained in detail on pages 125, 128, 132.

As to mode of occurrence, these red and green slates occur in places in proximity to white-weathering greenish or black, more or less quartzose shales or slates, and they also seem at several points to replace the Ordovician grit along the strike. Certainly these slates occur in as close proximity to the Cambrian slates as the grit. Black shales abounding with graptolites of the Normanskill fauna, as determined recently by Ruedemann, dip under the red slates on the west side of the now disused quarry a mile northeast of Middle Granville (locality 36, Pl. XX).

The red and associated bright-green slates are regarded as of the same general horizon as the Ordovician grits and their interbedded graptolite shales; and on the east the entire group (red and black slates and shales and grits) appears to pass along a meandering line extending from a point in Rupert, Vt., about a mile south of the Bennington County line, to the village of North Pawlet, Vt., on the north, merging gradually into the more highly metamorphosed sediments of the Taconic Range, the typical Berkshire schist, which is micaceous, chloritic, and in places also hematitic or graphitic. As the red slate appears to correspond to the lower part of the schist formation it is probably of middle Trenton age.

The cause of the abundant hematite to which the red slate owes its color may be sought in the beginning of a gradual elevation of a land surface that owing to long-continued weathering had become covered with somewhat thick deposits of rusty clays, which were then carried into the sea. These fine limonitic clayey sediments, when later subjected to the compression that metamorphosed the clay into fibrous muscovite and set up slaty cleavage, became reddish by the loss of the combined water and the change of limonite into hematite. The beds of bright-green slate may be attributed, like the spots and small greenish beds (p. 25), to the effect of decomposing marine organisms reducing the iron in the clays or to the original absence of iron therefrom.

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[1] U. S. Geol. Survey Nineteenth Ann. Rept., pt. 3, Pl. XIII, 1899.

Beds of red and green slate alternate vertically and replace c
another along the strike and also pass into shales of the same colo
The thickness exposed at the quarries reaches 50 and 75 feet, mos
red, with about 25 feet of green overlying, but after subtracting th
which is too hard or too soft or badly veined, there remains in pla
but 10 feet, rarely more than 25 feet, and at a maximum 42 feet,
good red slate exposed at any one quarry. Owing to the charac
of the folds and their pitch, as well as the merging of the colors alo
the strike, it is not easy to ascertain the total thickness of the r
and green. A few feet or inches of dark-red or purple slate is in so
places interbedded with the red. Beds of greenish quartzite, loca
calcareous, bordered by a purple slate, the whole ribbon measuri
an inch or two in thickness, are not uncommon (Pl. II, *A*), also be
half an inch thick of rhodochrosite (manganese carbonate) wi
crystalline calcite.

An analysis of this slate (specimen D. XIV, 1895, 201*d*), made
George Steiger, yielded the following:

Analysis of rhodochrosite bed.

Al_2O_3	0.68	MgO	2.
Fe_2O_3	.14	CO_2	25.
FeO	1.13	Insoluble matter, including all silica from dissolved silicates	32.
MnO	32.22		
NiO and CoO	.10		
CaO	3.81		98.

Under the microscope thin sections of this bed show, with polariz
light, a fine-grained bluish-brown matrix identical in color and te
ture with that of the small lenses in the red slate and with some
the lenses in the green slate; also large areas of calcite and son
quartz.

Both red and green slates also contain veins of quartz, some
which is crystallized, and in the red slate are light-green spots wi
or without a purple rim. Both red and green slates are in mar
places speckled with lenses. (See p. 91.) The bedding planes a
locally covered with glistening annelid trails and with impressio
that may have been made by algæ. Thin films of barite and calci
occur on the joint planes.

The location of the more important red-slate quarries in the town
of Granville and Hampton is shown on Plate XX. The structure
two of the quarries is shown diagrammatically in figs. *H* of Pla
XXIII and *U* of Plate XXIV, and the compass courses at the larg
quarries, with reference numbers to their location on the map (P
XX), are given below, but Nos. 33, 39, and 41 lie west of the ar
mapped; 33 is 3½ miles north-northeast of Middle Granville, in Gra
ville Township; 41 is 2⅛ miles northeast of Middle Granville, also
Granville; and 39 is 2¾ miles west of Jamesville, in Whitehall.

Compass observations at New York red-slate quarries.

Quarry No. on Plate XX.	Bedding.		Cleavage.		Strike joints.	
	Strike.	Dip.	Strike.	Dip.	Strike.	Dip.
33	N.	30± E.				
34	N.	45° E.				
35	N.+	15° E.	N. 15° E.	20° E.		
36	N. 5° E.	45° E.	N. 5° E.	30° E.	N.+	55° E.
37	N. 12° W.	35° E.	N. 12° W.	35° E.		
38	N. 10° W.	25° E.	N. 5° W.	30° E.	N. 10° W.	25° E.
39	N. 5° E.	50° E.	N. 5° W.	45° E.		
40	N.	35° E.	N.	40° E.		
41	N.	30° E.	N.	40° E.	N. 15° W.	50° E.
64	N. 15° W.	22° E.	N.	25° E.		
66	N. 30° W.	20° E.	N. 15° W.	25° E.		

Quarry No. on Plate XX.	Dip joints.		Diagonal joints.		Shear zones ("hogbacks").	
	Strike.	Dip.	Strike.	Dip.	Strike.	Dip.
33			N. 30° E.	70° W.		
34	N. 65° W.	90°				
35						
36	E.-W.	90°				
37						
38	N. 75° W.	90°				
39						
40					N. 7° E.	77° E.
41	N. 77° E.	90°				
64						
66	N. 80° W.	90°			N. 55° W.	70° NE.

THE SLATES.

Red slate.—The "red" slate is a decidedly reddish brown, becoming brighter on exposure. To the unaided eye its texture is fine, and its cleavage surface varies from slightly roughish to speckled with minute protuberances ("eyes" or "knots"), in either case without luster. It is magnetitic, sonorous, and has an argillaceous odor. Some of it effervesces with cold dilute hydrochloric acid. Under the microscope it shows a matrix of muscovite (sericite) with somewhat faint aggregate polarization, but this faintness is due partly to obscuration by carbonate and hematite, many of the plates of the former remaining light when all the mica is dark and the hematite darkening the mica when it is light. Distributed throughout the matrix are multitudinous bright-red hematite dots of circular or irregular oval outline, measuring from 0.0004 to 0.009 millimeter. There is much irregularity in the size of the particles, indicating but a fair grade of fissility. The larger particles consist of quartz fragments up to 0.06 by 0.03 millimeter, rare grains of plagioclase feldspar and of zircon, all detrital, considerable carbonate in rhombs or plates up to 0.047 millimeter, scales of chlorite interleaved with muscovite, up to 0.075 by 0.036 millimeter, a very variable number of lenses up to 0.34 by 0.15, rarely 0.5 millimeter long, consisting probably of rhodochrosite (carbonate of manganese) and chalcedonic quartz (containing carbonate rhombs and muscovite scales and in some places partial pseudomorphs of chlorite after carbonate), and finally some tourmaline prisms up to 0.005 by 0.001 millimeter.

The chief constituents of the red slate, named in descending order of abundance, appear to be muscovite, quartz, hematite, kaolin, carbonate, chlorite, magnetite, and rhodochrosite. For colored lithographs of magnified thin sections of this slate, as seen under both ordinary and polarized light, see Nineteenth Annual Report U. S. Geological Survey, part 3, Plate XXVIII, *A*, *B*, *C*. For a discussion of the causes of the green and purplish spots which occur here and there in this slate see pag of this bulletin. Associated with the red slate is generally a little purplish sl some of it speckled, of no commercial importance. Under the microscope it sh less hematite and possibly more chlorite than the red slate. Analysis N, be shows that it contains from 2½ to over 4 per cent less hematite and about one-thir 1 per cent more ferrous oxide than the red.

The following analyses were made in the chemical laboratory of the United St Geological Survey, the complete analyses by W. F. Hillebrand, the partial one George Steiger:

Analyses of red slates from New York.

	J	K	L	M	K^2	
Silica (SiO_2)	67.61	67.55	56.49	63.88		
Titanium dioxide (TiO_2)	.56	.58	.48	.47		
Alumina (Al_2O_3)	13.20	12.59	11.59	9.77		
Ferric oxide (Fe_2O_3)	5.36	5.61	3.48	3.86	7.10	
Ferrous oxide (FeO)	1.20	1.24	1.42	1.44	1.00	
Manganous oxide (MnO)	.10	.19	.30	.21		
Nickelous oxide (NiO)	Trace?	Trace.	Trace.	Trace.		
Cobaltous oxide (CoO)	Trace?	Trace.	Trace.	Trace.		
Lime (CaO)	.11	.26	5.11	3.53		
Baryta (BaO)	.04	.31	.06	.05		
Magnesia (MgO)	3.20	3.27	6.43	5.37		
Potassa (K_2O)	4.45	4.13	3.77	3.45		
Soda (Na_2O)	.67	.61	.52	.20		
Lithia (Li_2O)	Trace.	Trace.	Str. tr.	Str. tr.		
Water below 110° C (H_2O)	.45	.40	.37	.27		
Water above 110° C. (H_2O)	2.97	3.03	2.82	2.48		
Phosphoric oxide (P_2O_5)	.05	.10	.09	.08		
Carbon dioxide (CO_2)	None.	.11	7.42	5.08		
Pyrite (FeS_2)	.03	.04	.03	Trace.		
Sulphuric oxide (SO_3)	Trace.	Trace.	Trace.			
Carbon (C)	None.	None.	None.	None.		
	100.00	100.02	100.38	100.14		
Total sulphur (S)	.016	.02	.016			
Specific gravity			2.7839		2.8085	

J (D. XIV, 1895, 358*d*), red slate, H. H. Matthews's quarry, 1 mile west of Poultney, in Hampton, W ington County, N. Y.

K (D. XIV, 1895, 201*e*), red slate, Empire Red Slate Co.'s quarry, 1 mile north of Granville, in Gran Washington County, N. Y.

L (D. XIV, 1895, 397*e*), red slate, National Red Slate Co.'s quarry, 1 mile north-northwest of Racev in Granville, Washington County, N. Y.

M (D. XIV, 1895, 397*a*), red slate, same locality as L, but near a green and purple spot.

K^2 (D. XIV, 1895, 201*h*), red slate, same as K, but finer grained.

N (D. XIV, 1895, 284*a*), purple bed in red slate at Fair Haven Red Slate Co.'s quarry (not worke miles north of Truthville, in East Whitehall, Washington County, N. Y.

For presence of chromium and vanadium in these see Dr. Hillebrand's note, p. 58.

Some points in these analyses are discussed by Dr. Hillebrand on pages 58, 59.

As these red slates do not discolor and yet show a considerable amount of carbon under the microscope, and as the discoloration of the "sea-green" slates of Vermon due to the oxidation of a ferrous carbonate, it may be inferred that the carbon here is chiefly one of lime and magnesia, but the effect of a very small percentag ferrous carbonate would probably be masked by the brightness of the hematite.

J. F. Williams reported for this slate a modulus of rupture of 7,310 pounds to square inch, and Merriman 126.66 foot-pounds of work to the pound of slate as a re of impact tests. The results of Merriman's other tests of this slate are given on page 1

Bright-greenish slate.—The reddish slate is usually interbedded and exception passes along the strike into a light bluish-green slate, brighter in color than "unfading green" Cambrian slates of Vermont. Its color is peculiarly bright lamplight; its texture and surface are similar to those of the "red," and the surf is also in places speckled with minute lenses. It is magnetitic, effervesces v slightly with cold dilute hydrochloric acid, is sonorous, and is said to be unfading Under the microscope it shows a matrix of muscovite (sericite) with a more brilli aggregate polarization than that of the red slates, which may be due to the abse of the hematite, but the coarseness of the particles does not indicate a superior fissility. There are quartz grains up to 0.084 by 0.056 millimeter, chlorite scales up to 0.043 millimeter, some carbonate rhombs from 0.002 to 0.056 millimeter, and lenses measuring up to 0.385 by 0.128 millimeter, that consist either of rhodochrosite or chalcedonic quartz inclosing very minute carbonate rhombs and chlorite scales. Sections parallel to the cleavage show these lenses with a more roundish outline. There are also particles of pyrite, tourmaline prisms, rutile needles, and grains of zircon.

The chief constituents of this slate, named in descending order of abundance, appear to be muscovite, quartz, chlorite, carbonate, magnetite, rutile.

Its color is due to the abundance of chlorite and is permanent.

The following analysis (specimen O=D. XIV, 1895, 397c), by W. F. Hillebrand, is of a bright-greenish speckled slate from the National Red Slate Co.'s quarry, 1 mile north of Raceville, in Granville, Washington County, N. Y.

Analysis of bright-greenish slate from New York.

Silica (SiO_2)	67.89
Titanium dioxide (TiO_2)	.49
Alumina (Al_2O_3)	11.03
Ferric oxide (Fe_2O_3)	1.47
Ferrous oxide (FeO)	3.81
Manganous oxide (MnO)	.16
Nickelous oxide (NiO)	Trace?
Cobaltous oxide (CoO)	Trace?
Lime (CaO)	1.43
Baryta (BaO)	.04
Magnesia (MgO)	4.57
Potassa (K_2O)	2.82
Soda (Na_2O)	.77
Lithia (Li_2O)	Trace.
Water below 110° C. (H_2O)	.36
Water above 110° C. (H_2O)	3.21
Phosphoric oxide (P_2O_5)	.10
Carbon dioxide (CO_2)	1.89
Pyrite (FeS_2)	.04
Sulphuric oxide (SO_3)	Trace.
Carbon (C)	None.
	100.08
Sulphur, total (S)	.022

Specific gravity, 2.7171.

The relatively high percentage of magnesia is attributed to the abundance of both dolomite and chlorite.

The results of Merriman's tests of the bright-greenish slates quarried by the Mathews Consolidated Slate Co. are given on page 183.

Black slate.—Black roofing slate of Ordovician age was quarried many years ago, in a small way, 3 miles south of Hoosick Falls, near Hoosick, and also, at a later time, 2 miles south of Stephentown, near Lebanon Springs, in Rensselaer County, N. Y., but did not prove to be of economic importance at either locality.[1]

The principal features of the slates of New York as brought out in the above descriptions will be found in tabular form opposite page 188.

PENNSYLVANIA.

GENERAL FEATURES.

The slates of Pennsylvania, aside from those of Lancaster County and the southeastern part of York County, which are known as the Peach Bottom slate (pp. 110–115), occur chiefly in Northampton and Lehigh counties in a strip from 2 to 4 miles wide on the south side of Blue Mountain, extending from Delaware Water Gap in a west-southwest direction to a point 4 miles west of Lehigh Gap, a distance

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[1] Pl. CI and fig. 26, Thirteenth Ann. Rept. U. S. Geol. Survey, pt. 2, 1892, show the structure at the Lebanon Springs quarry.

of about 32 miles. The chief centers of the slate industry here are
Bangor and Slatington. The geographic relations of these pla
and of the other groups of slate quarries in these counties are sho
on the maps of the Second Pennsylvania Geological Survey, in M
rill's "Stones for building and decoration" (third edition), and
Merriman's article in Stone for July, 1898.

The map, Plate XV, compiled from that of the Second Pennsylv
nia Geological Survey by C. A. Bonine, shows the quarry sites
Northampton County as approximately determined by him in 19

The general geologic relations of this slate are these: On the sou
east, forming an east-northeasterly belt between Easton and Readi
and beyond, are the pre-Cambrian gneisses, etc., of South Mounta
flanked and dotted over with strips of Lower Cambrian quartzite a
sandstone. Northwest of this belt and parallel to it is a great Ca
brian and Ordovician dolomite and limestone plain from 3 to 6 mi
wide, under which the quartzite dips. Still farther northwest is
slightly hilly belt of Ordovician shales, grits, and roofing slates (t
Martinsburg shale), from 6 to 8 miles wide. At the southeast th
shales and slates overlie the limestone, and at the northwest they
under the Silurian conglomerate and sandstone of Blue Mounta
The boundary between the shale and slate formation and the lin
stone is roughly parallel to the general course of the Shawangunk co
glomerate boundary but passes a little north of Nazareth. In Carb
County, northwest of Blue Mountain, lies a strip of shales and slat
much resembling the Ordovician beds which dip under the Siluri
conglomerate on the southeast, but which Rogers (section 2, Pen
sylvania Survey) represented as overlying that conglomerate c
formably and thus as of Silurian age. Slate has also been prospect
in Dauphin County about 55 miles southwest of Lehigh County a
southeast of Blue Mountain.

The shale and slate formation measures from a minimum expos
of 1,600 feet to an estimated maximum of [illegible] feet, but of this o
a few hundred feet is commercial slate. In structure this formati
consists of a succession of minor close folds, generally overturn
northward, so that their axial planes have a general southerly d
but usually the synclines so formed have a steeply inclined southe
and a gently inclined northern limb. In places the fold is extreme
close and the overturn so complete that its axial plane has a ve
low southeasterly dip. The cleavage dips southward at various angl
as low as 5°, pointing, like the curvature of cleavage and jointing,
a secondary movement. These folds vary greatly in width and th
axes also pitch alternately east-southeast and west-northwest
angles ranging from 5° to [illegible]. They also bend laterally from no
to south. These folds have been more or less truncated by surfa
erosion, and in places the cleavage foliation has been crushed a

bent over to the south by the friction of the southward-moving ice sheet.

"Ribbons," or small beds of grit, measuring from a fraction of an inch to 2 feet in thickness, characterize the slate belt throughout. (See Pls. V, *B*; VI, *A*; XVII; and XVIII.) This grit consists mostly of more or less angular grains of quartz and feldspar, rarely of shale and quartzite, together with scales of muscovite and lenses of chlorite, spherules of pyrite, and carbonaceous matter, all in a cement of calcite and sericite with rhombs of carbonate more or less altered to limonite. The ribbons, as explained on page 11, represent coarse sediments, brought in, probably, by local marine currents.

Commercial slate is obtained along two belts. The upper and northerly one, known as the "soft vein," which is separated from the overlying Silurian conglomerate by an uncertain thickness of shale and slate, consists of beds of relatively soft slate of sufficient thickness between the ribbons to furnish large slabs suitable for mill stock or roofing. The lower and southerly belt, the "hard vein," near the base of the Ordovician formation ("Hudson"), consists of small beds of harder slate separated by small ribbons which are not coarse enough to interfere with their use either as mill stock or roofing slate.

The Bangor, East Bangor, Pen Argyl, Danielsville, Slatington, and Slatedale quarries are in the "soft vein" belt and the Belfast and Chapman are in the "hard vein." To judge from the map of the Second Geological Survey of Pennsylvania, which represents a limestone area, presumably anticlinal in structure, as extending from the Delaware near Portland to the vicinity of East Bangor, the "hard vein" ought to recur there near the limestone.

The following notes on the general stratigraphy of this slate belt and on the relations of the slate to the overlying Silurian conglomerate are contributed by C. A. Bonine, of this Survey, from his Lehigh University thesis on "The slate deposits of Northampton County, Pa.," written in 1912:

> In going up either the Delaware or the Lehigh River at right angles to the strike it is evident even to the most superficial observer that there are three lithologically different types represented in the formation. Farthest south the beds of slate are hard and close together, possess a good cleavage, and are occasionally interbedded with sandstone. Northward the formation changes gradually into beds of almost pure sandstone with very few shaly beds, and still farther north up to the Shawangunk conglomerate the material is again nearly all slate, which is soft, thick bedded, highly fissile, and interlayered with only occasional sandy beds. In the lower portion the "hard vein" slate is found and in the upper the "soft vein." The Delaware River section, along which the most reliable exposures were found, shows clearly that the Martinsburg shale is divisible into three parts—a lower hard thin-bedded shale and slate, a middle member of sandstone, and an upper member of shale and slate, which is soft and thick bedded. From this section it will be seen that the "soft vein" slate is found only near the mountains, because the land farther south along the axis of the syncline has been reduced by erosion to such an extent that the upper soft member

of the formation has been entirely removed, leaving exposed only the middle portion.

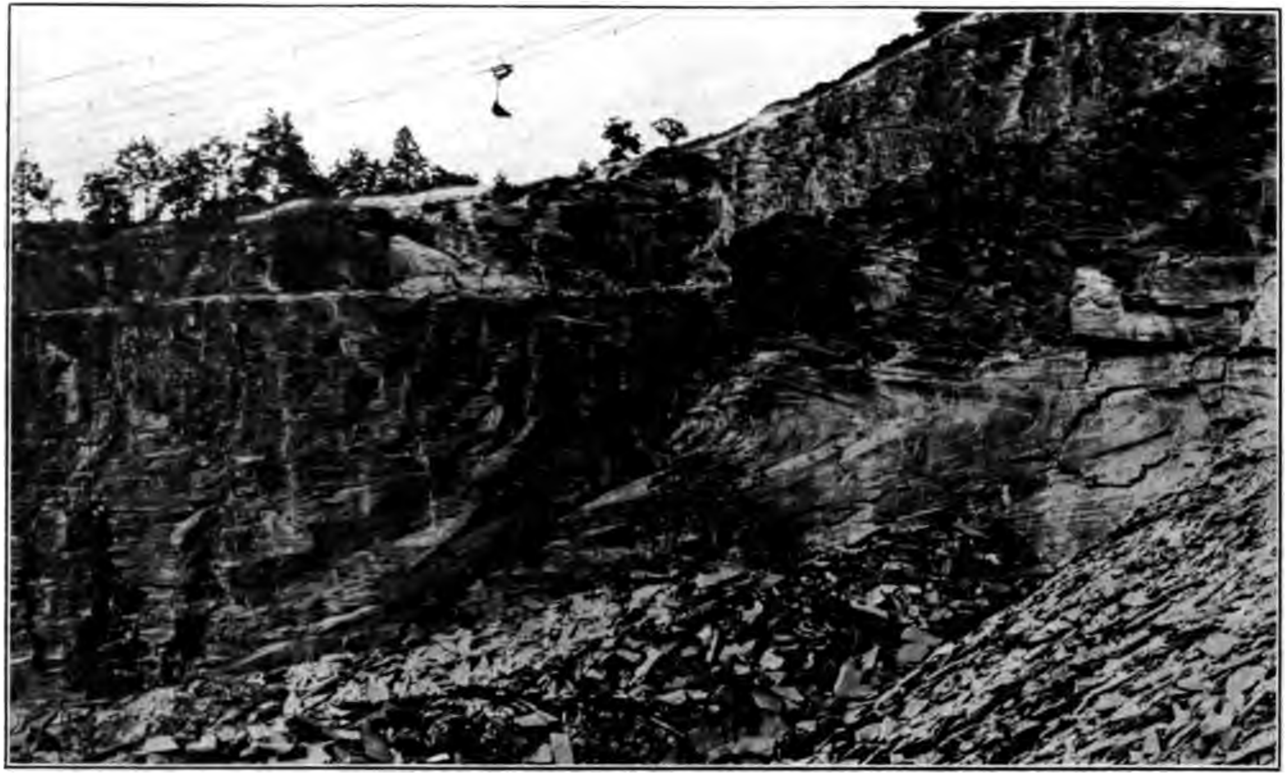
A close examination of the beds of the Shawangunk conglomerate near th shows included fragments of the underlying shale. The contact between this tion and the Martinsburg shale underneath is well exposed in a new cut of the & New England Railroad at Lehigh Gap. The dips here are not conformable, the conglomerate being 20° N. 45° W. and that of the slate 40° N. 45° W. Th also strong indications of a considerable erosional interval, as shown by the tional bed of soil material and pebbles.

All the more important features of the slates of Pennsylvani set forth in tabular form in the section on the comparative ch teristics of slates (p. 188). The literature of the slate of Northam and Lehigh counties is listed in the bibliography on pages 205- under the names Chance, Lesley, Merrill, Merriman, Rogers (H. and Sanders.

A few typical quarries and slates from these belts will no described.

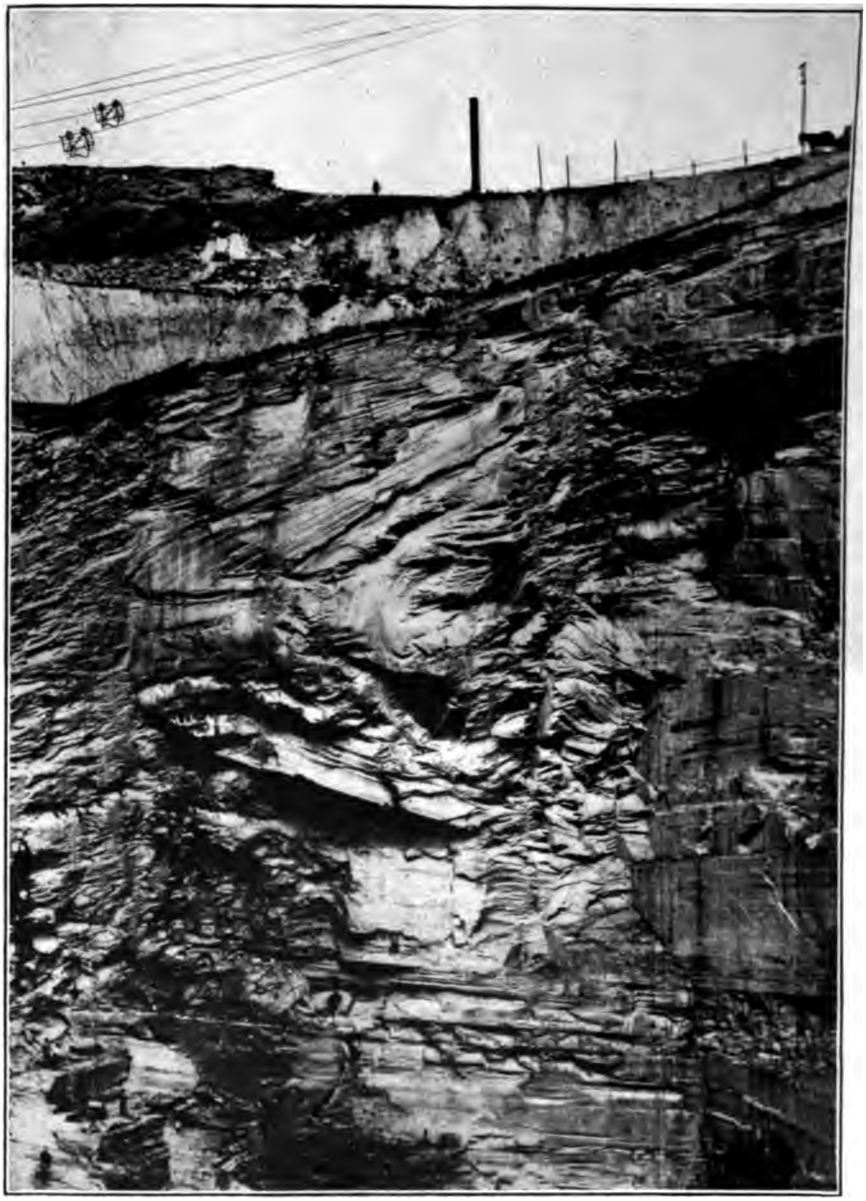
NORTHAMPTON COUNTY.

Bangor.—The "Old Bangor" quarry at Bangor, now operate J. S. Moyer & Co., is the largest slate quarry in the United States the oldest one in this region. It is regarded as being near the t the "soft vein" belt. It measures over 1,000 feet along the st 500 feet across it, and from 200 to 300 feet in depth. (See Pl. and map of Delaware Water Gap quadrangle, United States Geolo Survey.) The general structure is that of a close overturned cline, striking about N. 25° E., with an axial plane dipping southeast at a low angle and pitching 5°–10° SSW., crosse cleavage dipping 5°–10° S. 32° E. The same gritty bed appea both the top and the bottom of the quarry, and this bed is garded as the lower limit of the slate, drill cores from a depth of feet below the quarry having failed to show any good slate. thickest bed of good slate is 9 feet thick. In 1912 that part of gritty bed overlying the good slate of the syncline was being bla out and thrown down upon the gritty bed below it as fast as the slate was quarried out. Vertical diagonal joints striking N. 52° E. are conspicuous. There are also vertical dip joints and zontal joints. Curvature of the cleavage occurs here and t Certain diagonal or longitudinal joints intersecting the bedding pl at the northern corner of the quarry produced an optical illusion the beds there seemed to curve over to the west-northwest inste the east-southeast, and thus, in connection with the syncline on east-southeast wall, to form a complete ellipsoid. This pec feature, however, is fast disappearing with the growth of the vation. The ribbons are markedly more calcareous than the and in weathering become white from incrustation of lime.



OLD BANGOR QUARRY (NORTH-NORTHEAST END), BANGOR, PA.

Showing close, flat syncline crossed by nearly horizontal cleavage. Taken in 1912. The shanty at the foot of the working face shows the scale.



BANGOR UNION QUARRY, BANGOR, PA.

Looking N. 8° W. Showing inner part of flat syncline of Plate XIII. Distance between the strike of the two about 500 feet. Taken in 1912.

of white calcite and quartz, 4 inches thick, occur in the strike joints. Crystalline films of gypsum form on the horizontal joint faces.

Mr. Bonine obtained the following names and order of the beds at this quarry from the foreman in 1912:

1. Surface (glacial débris, weathered slate).
2. Hard roll.
3. Big bed, 4 feet.
4. Thirteen beds.
5. Seven beds, 25 feet.
6. Five beds.
7. Hogback run, 10 feet.
8. Gray bed run, 13 feet.
9. Big bed, 3½ feet.
10. Schuman run.
11. Feathery run.
12. Black ribbon run.
13. Five beds.
14. Mill run, 3 feet.
15. Big bed, 4 feet.
16. Nine-foot bed, 9½ feet.

Sand slate rock.

The slate from the "Old Bangor" quarry is very dark gray and to the unaided eye has a fine texture and a fine cleavage surface, almost without any luster. The sawn edge shows pyrite. It contains very little magnetite, is carbonaceous or graphitic, effervesces with cold dilute hydrochloric acid, is sonorous, and has an argillaceous odor.

Under the microscope this slate shows a matrix of muscovite (sericite), with a brilliant aggregate polarization, somewhat obscured by abundant carbonate in plates and rhombs. The cleavage is regular, but the particles are coarse. There are scattered chlorite scales up to 0.124 by 0.066 millimeter; quartz grains not very abundant up to 0.047 millimeter. Pyrite spherules number about 14,000 per square millimeter, measuring up to 0.01 millimeter in diameter. Rutile needles are very plentiful. Carbonaceous or graphitic matter occurs in fine particles throughout.

A transverse section of a coarse ribbon from this quarry showed, under the microscope, bedding crossed by cleavage at an angle of 27°, a matrix of sericite in irregular stringers, without any aggregate polarization, and carbonate and carbonaceous matter, containing angular quartz grains up to 0.17 by 0.12 millimeter, feldspar grains (plagioclase, orthoclase) up to 0.14 by 0.09 millimeter, the quartz and feldspar together making up no more than 25 per cent of the ribbon; also spherules of pyrite up to 0.07 millimeter, some of them in lenses of chlorite; some large plates of muscovite and of chlorite interleaved with muscovite, up to 0.06 millimeter, and rarely a zircon fragment, 0.03 millimeter.

The constituents of this slate, named in descending order of abundance, appear to be muscovite, carbonate, quartz, kaolin, pyrite, chlorite, rutile, magnetite, and carbonaceous matter.

The final results of Merriman's physical and chemical tests of slate from the "Old Bangor" quarry are given here for convenience of reference: Strength (modulus of rupture), 9,810 pounds to the square inch; toughness (ultimate deflection on supports 22 inches apart), 0.312 inch; density (specific gravity), 2.780; softness (amount in grains abraded by 50 turns of a small grindstone), 128; porosity (cent of water absorbed in 24 hours), 0.145; corrodibility (per cent weight lost in 63 hours in acid solution composed of 98 per ce H_2O, 1 per cent HCl, 1 per cent SO_3), 0.446. Per cent of lime, 4. computed carbonate of lime, 7.82 per cent; computed carbonate magnesia, 5.65 per cent.[1]

The product from the large beds is used for roofing, but that fr the ribboned beds goes into mill stock.

The Bangor Union quarry, now operated by William E. Lloyd, Bangor, lies about 500 feet northwest of the northwest wall of t "Old Bangor" quarry. The opening, estimated by Mr. Bonine measuring 400 by 200 feet, exposes a completely overturned cl fold on its northwest wall, crossed by an almost horizontal cleava as shown in Plate XIV. This fold is regarded as the inner nor westerly part of that exposed on the northeast wall of the "(Bangor" quarry, shown in Plate XIII. The general strike is ab N. 45° E.

Mr. Bonine has furnished the following note on the beds:

> This quarry has some beds that are not present in the "Old Bangor" quarry beca it is farther up in the fold. These new beds are:
>
> 1. Bangor Union big bed.
> 2. Spar ribbon.
> 3. Waste, 4 feet.
> 4. Pinhead run.
> 5. Magpie run.
> 6. Waste, 6 feet.
> 7. Black ribbon big bed.
> 8. Shellbark run.
> 9. Spar ribbon.
> 10. Waste, 4 feet.
> 11. One-length factory.
> 12. Waste, 4 feet.
> 13. School and factory.
> 14. Hard roll.
> 15. Factory.
> 16. Three beds.
> 17. Two beds.
> 18. Hard roll.
> 19. Fine ribbon.
>
> Below this the beds occur as named in the "Old Bangor" (p. 97). At the prese time this quarry has only been worked down as far as the "Gray bed run," No. 8 of t "Old Bangor" section.

The ribboned slates from this quarry reach the market in tw grades. In grade No. 1 the ribbons occur only in one-half of the su face, which on the roof can be covered by the overlapping tier. Grad No. 2 has ribbons all over and the cleavage is likely to be bent slightl at the ribbon.

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[1] Am. Soc. Civil Eng. Trans., vol. 27, pp. 342–347, 1892.

North Bangor.—The large quarry of the North Bangor Slate Co. is about 200 feet square and 350 feet deep. The folded beds strike about N. 60° E. and the cleavage dips 15° SW. The total thickness of good slate here, measured across the cleavage, is 300 feet. In the smaller quarry the thickest bed measures 9 feet and is reserved for blackboards. It is thought that the gritty bed which underlies and overlies the good slate at the "Old Bangor" quarry has been struck at the bottom of this one.

The slate from these quarries is very dark gray and to the unaided eye has a fine texture and a very smooth cleavage surface, with but slight luster. It is somewhat carbonaceous and contains some magnetite. The sawn edge shows pyrite. It effervesces somewhat freely with cold dilute hydrochloric acid, is sonorous, and has an argillaceous odor.

Specimens from the North Bangor Slate Co.'s quarry show, under the microscope, a matrix of muscovite (sericite) with a somewhat brilliant aggregate polarization and a general uniformity in size of particles. The aggregate polarization is partly obscured by the very abundant carbonate. Quartz fragments are not very abundant and measure up to 0.04 millimeter. There are some chlorite scales up to 0.09 millimeter and about 10,000 spherules of pyrite, measuring up to 0.01 millimeter, to each square millimeter, also carbonaceous matter or graphite and very abundant rutile needles.

The constituents, named in descending order of abundance, appear to be muscovite, carbonate, quartz, kaolin, pyrite, chlorite, magnetite, rutile, and carbonaceous matter or graphite. In a black-ribboned piece from the same quarries the half-inch ribbon shows much carbonaceous matter and many spherules of pyrite. The quartz particles and the plates of carbonate are larger in the ribbon than in the adjacent slate.

The product of this company's quarries is used for blackboards, billiard tables, fireboards, stationary tubs, well covers, tiles, lathe work, etc.

East Bangor.—The large quarry of the East Bangor Consolidated Slate Co. measures 350 feet along the strike and 700 feet across by 130 feet in depth. The beds dip 5° NNE. and the cleavage 15°–20° SSW. The main joints strike north and undulate in a general vertical direction. The grain strikes N. 50°–60° W. Ribbons are numerous.

The slate is very dark bluish gray and to the unaided eye has a fine texture and a somewhat fine but almost lusterless cleavage surface. It is both carbonaceous, or graphitic, and magnetitic. The sawn edge shows a little pyrite. It effervesces slightly with cold dilute hydrochloric acid, is sonorous, and has a scarcely perceptible argillaceous odor.

Under the microscope a specimen taken between "ribbons" shows a matrix of muscovite (sericite) with a brilliant aggregate polarization, somewhat obscured by carbonate, a texture a little finer than that of the slate of the "Old Bangor" quarry, but carbonate as abundant as in that. Not very much quartz in grains measuring up to 0.04 by 0.02 millimeter; about 250 scales of chlorite, with interleaved muscovite, to each square millimeter, measuring up to 0.07 by 0.03 millimeter, exceptionally 0.08 by 0.04 millimeter; about 12,400 spherules of pyrite to the square millimeter, measuring up to 0.008 millimeter; rutile needles very abundant; carbonaceous or graphitic matter in fine particles.

The chief constituents of this slate, named in descending order of abundan
appear to be muscovite, carbonate, quartz, pyrite, chlorite, kaolin, rutile, carbo
ceous matter or graphite, and magnetite.

The product of this quarry is used both for roofing and for mi
stock, but not for blackboards, as the 9-foot bed is crossed by ribbo
The roofing slates are said to show comparatively little discolorati
after 30 years' exposure.

Windgap.—The group of quarries known as the Windgap quarr
is about a mile from the saddle in Blue Mountain known as the Wi
gap, which is about 11 miles southwest of the Delaware Water G
(See Pl. XV.) Three of these quarries were visited by the writer
1912.

The Alpha Slate Manufacturing Co.'s quarry, about a mile S. 35°
from the gap, is about 200 feet square and 70 to 150 feet deep. T
light-buff "top," of decomposed slate, is 50 feet thick. The b
strike N. 55° E. and dip 70° N. 35° W. The cleavage strikes N. 75°
and dips 25° S. 15° W. Beds free of ribbon are from 2 to 25 feet thi
About three-fourths of the product is used for mill stock and the r
for roofing. Channeling machines are used for both horizontal a
vertical cutting.

The Imperial quarry, operated by William Harding & Co., is abo
S. 30° E. from the gap and measures 175 feet along the bed by 150 f
across it and 200 feet in depth. The "top" consists of 75 feet of deco
posed and bad slate. The beds curve northward at a depth of 40 fe
below the "top." The thickest clear bed measures 11 feet along t
cleavage. The grain is diagonal to the ribbon. The product is us
mostly for mill stock, including blackboards. Channeling machin
are used altogether for vertical cuts, but powder is used for cuts alo
the grain.

The Phœnix quarry of the Phœnix Slate Co., of Windgap, Pa.,
about S. 20° E. from the gap and measures about 300 feet along t
bed by 175 feet across and from 70 to 170 feet in depth. The deco
posed slate of the top is 10 feet thick. The thicker beds free
ribbons measure 11 and 14 feet along the cleavage. The grain
diagonal to the ribbon. As shown in Plate V, *B*, the beds beg
to curve southward at the rock surface. Slabs of banded (ribbone
slate from this quarry are shown in Plate VI, *A*. The product
nearly all used for mill stock, including blackboards. At least one
the beds has been found suitable for electric switchboards.

Heimbach.—The Heimbach quarry, about 1½ miles northeast
Slatington, in Northampton County, is operated by Jay S. Moyer & C
There is a thick bed here known as the "Heimbach big bed," which
very dark gray and less bluish than the slate of the "Old Bangor
quarry.

RTHAMPTON C

To the unaided eye it has a fine texture and a somewhat fine but almost lusterless cleavage surface. It contains an exceedingly small amount of magnetite, effervesces with cold dilute hydrochloric acid, and is sonorous.

Under the microscope it shows a matrix of muscovite (sericite), with but faint aggregate polarization owing to the abundance of carbonate, which much exceeds that in the slate of the "Old Bangor" quarry. The cleavage is considerably finer and there is greater regularity in the size of particles than in that slate. There are a few chlorite scales up to 0.06 by 0.04 millimeter. Very little quartz is seen, in grains reaching only 0.036 millimeter. Pyrite spherules measure up to 0.012 millimeter and number about 18,000 to the square millimeter. Rutile needles are very abundant. The usual carbonaceous matter is seen.

The constituents of the "Heimbach big bed," named in descending order of abundance, appear to be muscovite, carbonate, quartz, pyrite, chlorite, rutile, carbonaceous matter, and magnetite, but the carbonate is more plentiful than in some slates in which its relative position is the same.

There is also in the same quarry a 6-foot bed, which is blacker than any of the other slates of Northampton and Lehigh counties. It has to the unaided eye a somewhat fine texture and cleavage surface with a slight luster. It shows pyrite on the sawn edge, is carbonaceous or graphitic and very slightly magnetitic, effervesces in cold dilute hydrochloric acid, is sonorous, and has a slight argillaceous odor.

Under the microscope the "Heimbach black bed" shows a finematrix of muscovite (sericite), with but faint aggregate polarization owing in part to the very large amount of carbonate and carbonaceous matter. The number of quartz fragments is relatively small and they measure up to 0.028 millimeter. There are chlorite scales up to 0.06 millimeter. Spherules of pyrite measure up to 0.008 millimeter, exceptionally 0.017 millimeter, and number about 6,800 to the square millimeter. Rutile needles abound. Rarely a scale of hematite is seen.

The chief constituents of this slate, named in descending order of abundance, appear to be muscovite, carbonate, quartz, carbonaceous matter and graphite (?), pyrite, chlorite, rutile, and magnetite. The percentage of carbonate is large.

The principal difference betwen the slates of the Heimbach and "Old Bangor" quarries is in the larger amount of carbonate, lesser amount of pyrite, and the fine structure of the former, to judge from the microsopic evidence.

Pen Argyl.—The Albion quarry, at Pen Argyl, is regarded as being near the bottom of the "soft vein" belt. It measures 650 feet along the strike, 600 feet across it, and 390 feet in depth. In 1904 it was operated by two companies, Wm. Lobb & Sons at the west end and Stephen Jackson & Co. at the east end. The structure is that of an S-shaped fold overturned to the north-northwest. The bedding strikes N. 58°-60° E.; cleavage at the north-northwestern edge dips 10° S., halfway down about 10° N., and at the bottom about 40° S. The grain is at right angles to the ribbon. At the north-northwestern edge of the quarry is a series of hard beds 40 feet thick. Under the microscope this rock shows no aggregate polarization and is seen to consist of the following minerals, named in order of diminishing abundance: Carbonate, quartz, chlorite, carbonaceous matter, muscovite, pyrite, and rarely plagioclase feldspar. It is a clay slate. Some of the beds are said to measure 20 feet between ribbons. There is an exceptional bed, 44 inches thick, of a dark, slightly greenish-gray slate of superior quality, described beyond. Vein matter on the dumps consists of vein quartz and calcite, the former predominating. Associated with these veins are plicated, very quartzose ribbons traversed by a coarse slip cleavage and also brecciated. Black slaty material has been pressed into the faults of the slip cleavage. One of these quartz masses was 20 feet thick and extended the entire length of the quarry.

The chief product of the Albion quarry is a very dark-gray slate which to the unaided eye has a fine texture and a roughish, almost lusterless cleavage surface. It is somewhat carbonaceous and magnetitic, shows pyrite on the sawn edge, effervesces slightly with cold dilute hydrochloric acid (considerably in the ribbon), and is sonorous.

Under the microscope this slate shows a matrix of muscovite (sericite), with brilliant aggregate polarization, somewhat obscured by abundant carbonate in plates and rhombs. The amount of carbonate is less than in the specimens from the "Old Bangor" and North Bangor quarries. Quartz is not very abundant, in grains measuring up to 0.04, rarely 0.09 millimeter. Scales of chlorite, interleaved with muscovite, are conspicuous, lying transverse to the cleavage, in places forming lenses with their long axes parallel to the cleavage, measuring up to 0.14 by 0.07 millimeter and numbering about 310 to the square millimeter. Pyrite spherules occur up to 0.01 millimeter and average about 1,085 to the square millimeter. There is finely disseminated carbonaceous (or graphitic) matter and a great abundance of rutile needles.

The mineral constituents, named in descending order of abundance, appear to be muscovite, carbonate, quartz, chlorite, pyrite, rutile, carbonaceous matter, and magnetite. The carbonate, although second, is not as abundant as in specimens from the "Old Bangor" quarry.

The results of Merriman's physical and chemical tests of the dark-gray ("black") slate from this quarry are here given for convenience of reference: Strength (modulus of rupture), 7,150 pounds to the square inch; toughness (ultimate deflection on supports 22 inches apart), 0.270 inch; density (specific gravity), 2.775; softness (amount in grains abraded by 50 turns of a small grindstone), 80; porosity (per cent of water absorbed in 24 hours), 0.238; corrodibility (per cent of weight lost in 63 hours in acid solution), 0.547; per cent of lime, 4.09; computed carbonate of lime, 7.40 per cent; computed carbonate of magnesia, 4.41 per cent.[1]

The dark greenish-gray slate of the Albion quarry has to the unaided eye a somewhat granular texture and a roughish and almost lusterless cleavage surface. It is not perceptibly carbonaceous or graphitic but is somewhat magnetitic. The sawn edges show pyrite. It effervesces slightly with cold dilute hydrochloric acid and is sonorous.

Under the microscope it shows a matrix of muscovite (sericite), with brilliant aggregate polarization. Quartz fragments measure up to 0.09 millimeter. There is considerable carbonate. There are chlorite scales, interleaved with muscovite, lying transverse to the cleavage and parallel to the grain; also chlorite scales transverse both to grain and cleavage, with inclusions of needlelike crystals, probably rutile, crossing one another, usually at 60° or 120°. All these chlorite scales average about 28 to the square millimeter, and measure up to 0.17 by 0.1 millimeter. The pyrite spherules measure up to 0.01 millimeter, and average about 968 to the square millimeter. Rutile needles also occur.

These constituents, named in descending order of abundance, appear to be muscovite, carbonate, quartz, chlorite, pyrite, rutile, and magnetite.

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[1] Merriman, Mansfield, loc. cit.

The product of the Albion quarry, at least that of the west end, is used for roofing.

Some of the other quarries at Pen Argyl show the passage of the black slate by weathering into a yellowish light-brown or even white shaly substance. The dumps afford specimens showing all gradations from black slate to white rock. The weathered zone in these quarries measures up to 40 feet in thickness. At one of them the beds of the truncated southern limb of an overturned syncline dip about 55° S. and the cleavage dips less than 10° in the same direction. The weathered top measures between 30 and 40 feet and is covered with 5 to 10 feet of subsoil. The weathering acids, taking advantage of the position of the bedding, have followed one of the ribbons and penetrated the workable slates to a depth of 60 feet below the weathered zone and have also commenced to work horizontally along the cleavage. This has resulted in the formation along the ribbon of a central bed of reddish-yellow ocher about 1 foot thick, with a 6-inch band of white on either side of it. The white portions here probably represent less ferruginous parts of the original sediment and not a later stage of weathering, for similar alternations of yellowish and white belts of weathered material occur in hand specimens crossing the cleavage. The workable black slate is thus traversed here by a 2-foot bed of yellow and white ochraceous material at an angle of 65° to the cleavage as the effect of weathering upon material and structure. The process here is mainly decarbonization. (See further, on the subject of weathering, p. 53.)

In this connection it should be stated that in the "soft vein" quarries generally, to judge from the dumps, the amount of iron and lime in the ribbon varies greatly. In some places pyrite or siderite predominates and limonitic staining ensues; in others lime is more abundant and a white calcareous crust forms. The slate flags on the sidewalks in the village of Bangor wear along the ribbons more rapidly than along the slaty portions.

Chapman.—The principal quarry at Chapman, which is in the "hard vein" belt, is operated by the Chapman Slate Co. It measures from 700 to 800 feet along a longitudinal joint striking N. 63° E. across it and is about 200 feet wide and 300 feet deep. In the center of the quarry is a completely overturned close syncline or anticline, still visible on the south-southeast wall of the quarry, striking N. 75°–78° E. and pitching gently eastward; but the lower limb of this fold opens out on the east-northeast and west-southwest walls so as to dip steeply northwest. This fold is crossed by cleavage striking N. 65° E. and dipping 14°–15° SSE. The principal joints are longitudinal, striking N. 63° E. and dipping 90°, forming two of the sides of the quarry. The grain strikes N. 37°–53° W. and dips 90°. The largest bed, which, although containing very small ribbons, can be used for roofing slate, measures 16 feet. The number of ribbons exposed on the eas northeast wall, where the fold opens out, is 112, averaging a litt over two to each foot of slate.[1]

Some quartz veins lying in the cleavage show a columnar structu parallel to the side of the vein. The "top" in an adjacent quarry the same company measures fully 50 feet.

The slate is very dark gray but is crossed by many ribbons a tri darker and measuring from one-eighth to one-half inch, which, ho ever, scarcely deflect the cleavage.

To the unaided eye it has a fine texture and a slightly roughish and slightly lustro cleavage surface. It is both graphitic (or carbonaceous) and magnetitic. The sa edge shows pyrite. Under cold dilute hydrochloric acid there is a slight effervescen but more in the ribbon. It is sonorous and discolors but slightly in 30 years' exposu E. H. S. Bailey gives the specific gravity as 2.79. For Merriman's recent tests of t slate see page 182.

Under the microscope the Chapman slate shows a matrix of muscovite (sericite) wi a brilliant aggregate polarization not obscured by carbonate. A ribbon of coa materials, 0.62 millimeter wide, crossing the cleavage at an angle of 14°, posses aggregate polarization. There are some large lenses of coarse quartz and carbona in the cleavage. There is considerable carbonate throughout, in plates and rhom but less than in the slate of the "Old Bangor" quarry. Quartz up to 0.06 millimet pyrite spherules up to 0.02 millimeter and numbering about 4,250 to the square mi meter; about 263 scales of chlorite, with interleaved muscovite to the square mi meter, lying across the cleavage and measuring generally up to 0.08 by 0.04 millimet graphitic or carbonaceous matter in fine particles; abundant rutile needles; rare gra of plagioclase feldspar. The ribbon contains more abundant and coarser quartz, c bonate, chlorite, and carbonaceous matter than the rest.

The important constituents, named in descending order of abundance, appear be muscovite, quartz, carbonate, pyrite, chlorite, rutile, carbonaceous matter graphite and magnetite.

The product of this quarry was formerly used largely for flaggin posts, steps, etc., and because of its hardness had to be cut with di mond saws which operated horizontally, but owing to the competiti of sandstone flagging and the high price of diamonds this outlet closed and the product is now used exclusively for roofing slate, f which, however, only selected material is available.

LEHIGH COUNTY.

Geologic relations.—The slate quarries of Lehigh County all belo in the "soft vein" belt. The relation of the "soft vein" slate to t shale of the same formation is well exposed near Lehigh Gap, on t border of the county. On the east side of the gap the outcrop of t Martinsburg ("Hudson") shale, of Ordovician age, that is nearest the so-called "Oneida" conglomerate is a black shale that occurs alternating thick and thin beds. The thick beds, being entire devoid of cleavage, weather into shelly fragments, and the thin one

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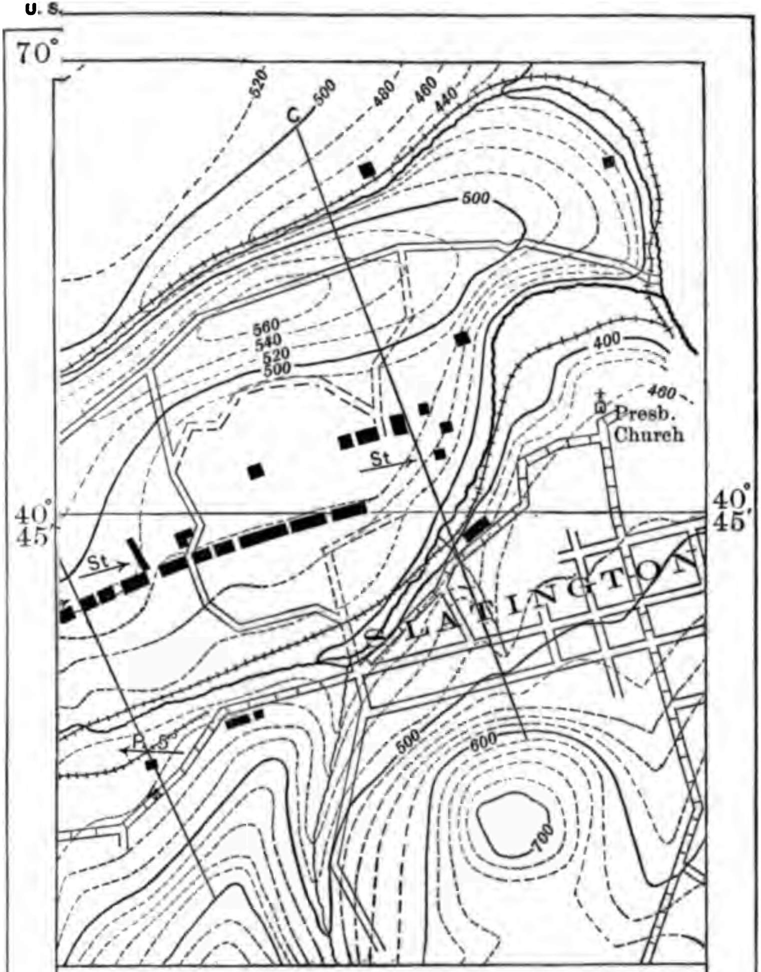
[1] Figures obtained through the courtesy of Mr. Richard Chapman, superintendent.



MAP OF

NGTON SLATE QUARRIES

PENNSYLVANIA

S. Geological Survey, Slatington quadrangle,
n additions by T. Nelson Dale.
ns by Fred H. Moffit, assistant geologist.

Scale

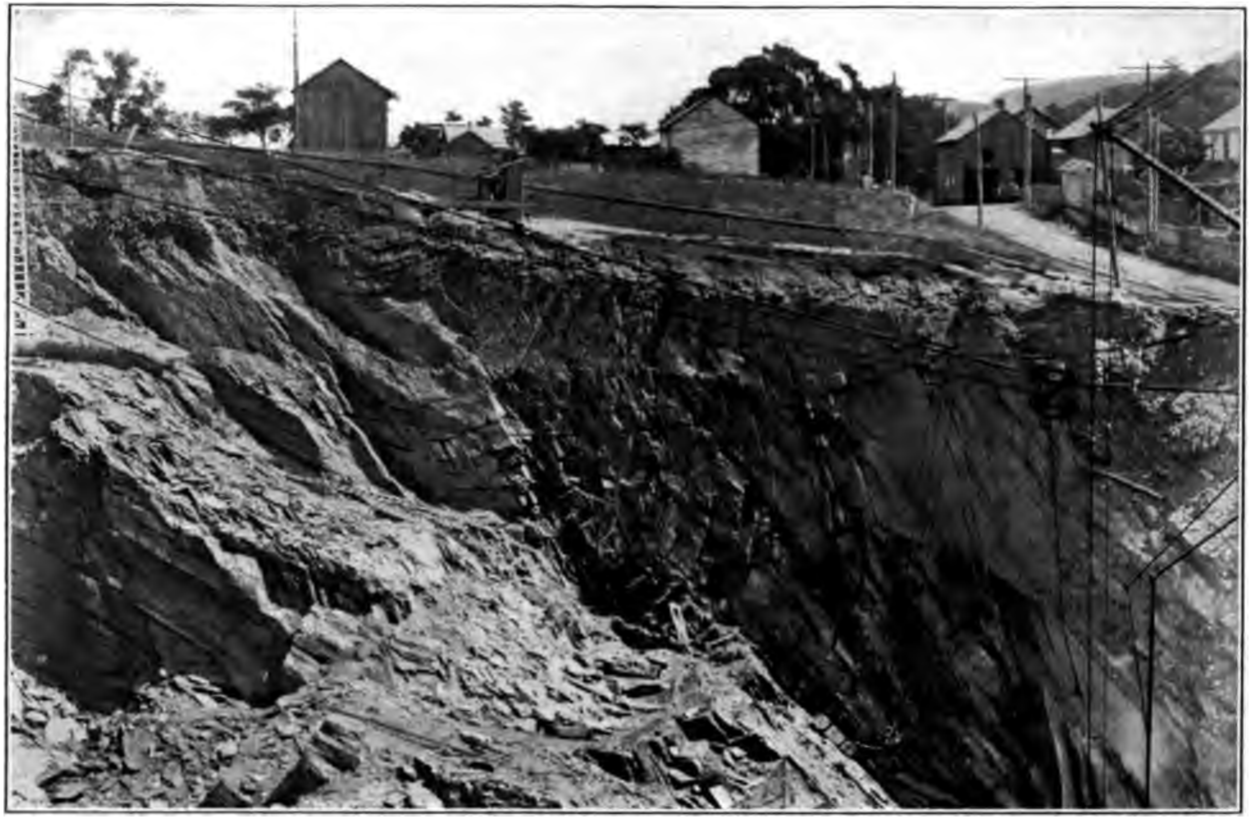
½ ¾ 1 mile

tour interval 20 feet.

1905.

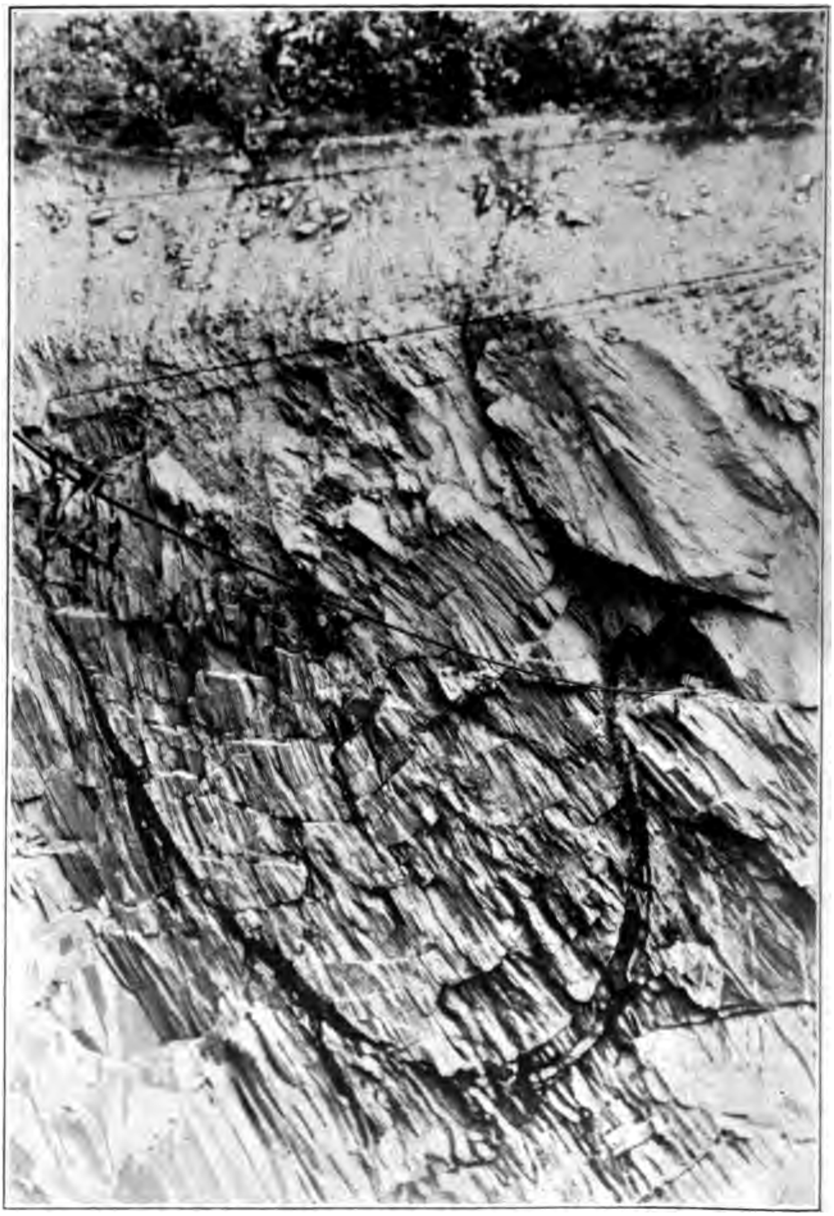
ed.
f pitch of axis of fold.

70



BLUE MOUNTAIN SLATE QUARRY, NEAR SLATINGTON PA.

Looking east. Showing the character of the syncline, its relation to the cleavage, and the southward bending of the cleavage at the surface, a bending probably due to glacial action.



NORTHERN PART OF EUREKA SLATE QUARRY, NEAR SLATINGTON, PA.

Looking east. Eroded northward-inclined close syncline, crossed by southward-dipping cleavage and undulating joints and overlain by residual clay and glacial deposits. The cleavage within the syncline appears to be curved also.

owing to the intersection of an incipient slaty cleavage with the bedding foliation, break up into sticklike fragments. Under the microscope the thin beds prove to be an aggregate of muscovite scales, quartz grains, and carbonaceous particles, with some pyrite spherules and limonite specks. Here and there the beginning of a slaty cleavage foliation is indicated by short stringers of fibrous muscovite lying at right angles to the bedding, but otherwise there is no alignment of particles and the rock is a typical shale. A hundred feet farther south a southward-dipping slaty cleavage predominates, and the northward-dipping bedding is shown only by an occasional ribbon. Therefore within a space of 200 feet the transition from a shale to a slate can be observed. In the slate the amount of secondary mica has greatly increased and the clastic particles of the shale have been forced into the same parallelism of arrangement.

In weathering the slates of Lehigh County undergo the same transformations as those of Northampton County. The black slate first passes into a soft yellowish-brown ocherous rock, which later becomes nearly white and finally passes into a white micaceous clay, the "shale clay" of the limonite and fire-clay pits. But these changes probably required many centuries. See discussion of chemistry of slate, page 53.

Slatington quarries.—The slate quarries of Lehigh County are now confined to an area comprising about 3 square miles along Trout Creek and its tributaries. This stream empties into the Lehigh from the west at Slatington. The accompanying map (Pl. XVI) includes all the quarries about Slatington which were in operation in 1902, 45 in number, together with 50 abandoned ones. The older quarries had in 1902 reached a depth of about 300 feet. The map shows the exact location of these quarries, their approximate dimensions at the surface, the strike of the beds, and both the direction and angle of the pitch of the folds. The lateral deflection of the strike amounts in places to 10°, if not a little over, and the pitch ranges from 5° to 10°.

The character of the folds in these quarries is shown in Plates XVII and XVIII and figures 7, 8, 9, 10. The relation of the workable beds to the ribbons is shown in Plate XVII. The strike ranges from N. 40° E. to east and to N. 86° W. The cleavage strike is N. 74°-85° E., and its dip 35°-75° S. 5°-16° E.

In places there is a difference in the angle of the cleavage dip in adjacent beds. The curvature of the cleavage at the "Old William Hughes" quarry amounts to a change of 20° in 25 feet of slope. There is usually a little curvature of the cleavage on either side of the ribbon. There is a conspicuous system of dip joints striking about north-south, some of which are shown in Plate XVII; also strike joints which locally undulate like bedding planes, as at the Eureka quarry (Pl. XVIII).

The quarrymen's names of the slate beds in the Slatington area are, from south to north, Williamstown, Blue Mountain, Trout Creek, Washington, Little Franklin, Big Franklin, Mammoth, New Bangor, Snowdon, and Eureka. It is uncertain whether some of these beds are not duplications, for the structure of the belt, as shown in the section on Plate XVI, indicates that they may be, and their relations have never been worked out mathematically. Examples of these beds ("veins") are the "Washington," which at the Hazel Dell quarry averages 27 feet in thickness or 40 feet measured along the cleavage,

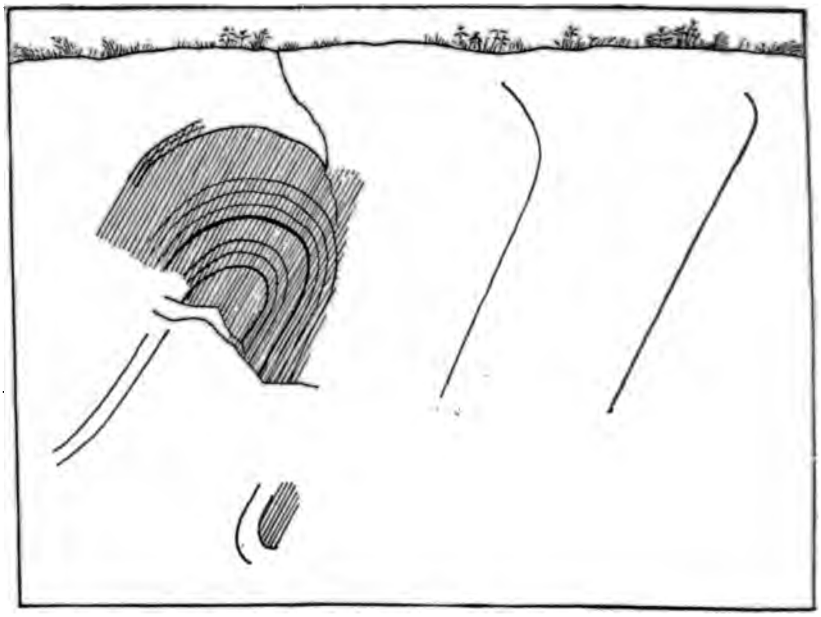


FIGURE 7.—Sketch of anticline in Provident Slate Co.'s quarry, near Slatington, Pa., looking west. Width represented, 50 feet.

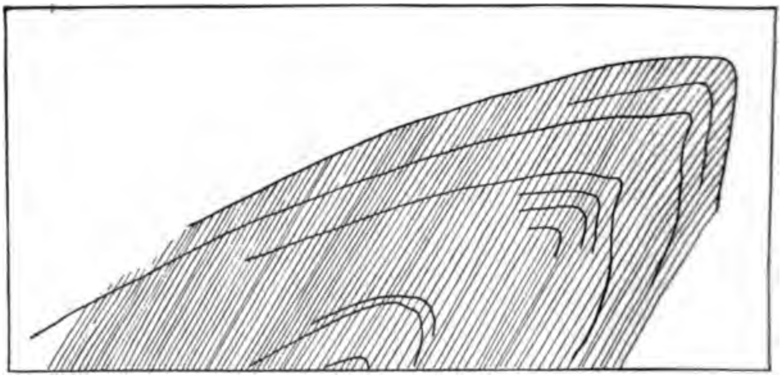


FIGURE 8.—Sketch of anticline in old quarry north of Slatington, Pa., looking west. Height represented, 25 feet.

and the "Franklin," at the "Old Franklin" quarry, which consists of an upper bed of 28 feet and a lower one of 35 feet, separated by about 25 feet of small ribboned material, the measurements being taken along the cleavage. In general the beds range from 3 to 30 feet in thickness, measured at right angles to the bedding.

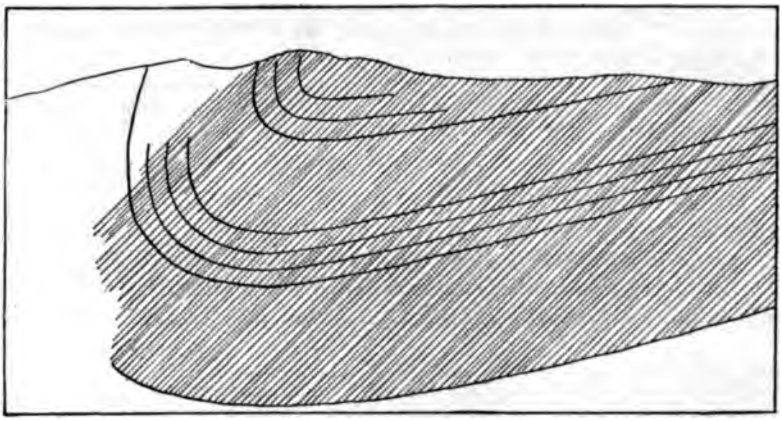


FIGURE 9.—Sketch of syncline at William Hughes's quarry, near Slatington, Pa., looking west. Length, 80 feet. Upper bed over 10 feet thick; lower bed 15 feet thick, but with marked curvature of cleavage.

The slate of the Slatington area is very dark-bluish gray. To the unaided eye it has a somewhat fine texture and cleavage surface, but it is almost lusterless. It is carbonaceous and slightly magnetitic. The sawn edges show little if any pyrite. It effervesces in cold dilute hydrochloric acid, is sonorous, and has some argillaceous odor. After prolonged exposure this slate becomes at first a dark gray and finally various shades of cream and coffee color, but the rapidity and degree of discoloration differ in different beds. Fissility fine.

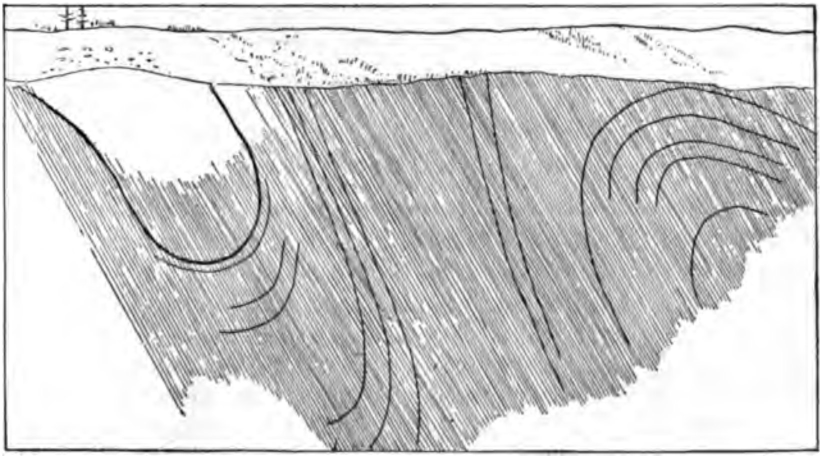


FIGURE 10.—Sketch of folds at Eureka quarry, near Slatington, Pa., looking east. Length, 350 feet; depth, 225 feet. The upper part of the syncline is shown in Plate XVIII.

Under the microscope it shows a matrix of muscovite (sericite) with a brilliant aggregate polarization, obscured, however, by much carbonate and carbonaceous matter. There are many angular grains of quartz up to 0.04 millimeter; rarely one of plagioclase; a few scales of chlorite, interleaved with muscovite, or of each separately, up to 0.08 millimeter, and numbering about 7 to the square millimeter, spherules of pyrite up to 0.012, rarely 0.02 millimeter., numbering about 11,000 to the square millimeter; very abundant rutile needles.

The principal constituents, named in descending order of abundance, appear to be muscovite, carbonate, quartz, kaolin, pyrite, chlorite, rutile, carbonaceous or graphitic matter and magnetite.

The following analyses were made by Dr. W. F. Hillebrand—A from the "Lower Franklin bed," Old Franklin quarry, Slatington; B from the "Washington bed," Hazel Dell quarry No. 1, Slatington.

Analyses of slates from Lehigh County, Pa.

	A (complete).	B (partial).
Silica (SiO_2)	56.38	56.85
Alumina (Al_2O_3)	15.27	[a] 15.24
Ferric oxide (Fe_2O_3)	[b] 1.67	[c] 5.32
Ferrous oxide (FeO)	[b] 3.23	
Magnesia (MgO)	2.84	2.93
Lime (CaO)	4.23	4.28
Soda (Na_2O)	1.30	1.38
Potassa (K_2O)	3.51	3.34
Water below 110° C. (H_2O)	.77	.45
Water above 110° C. (H_2O)	4.09	Not est.
Titanium dioxide (TiO_2)	.78	.84
Zirconium dioxide (ZrO_2)	Trace?	....
Carbon dioxide (CO_2)	3.67	3.58
Phosphoric oxide (P_2O_5)	.17	(d)
Chromium oxide (Cr_2O_3)	Trace?	Trace?
Manganous oxide (MnO)	.09	Not est.
Baryta (BaO)	.08	Not est.
Strontium oxide (SrO)	Trace.	Not est.
Lithia (Li_2O)	Trace.	Not est.
Pyrite (FeS_2)	[e] 1.72	[e] 1.72
Carbon of carbonaceous matter (C.)	.59	Not est.
	100.39	96.12
Specific gravity (21° C.)	2.783	2.780

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[a] Including P_2O_5.
[b] Approximate.
[c] As Fe_2O_3.
[d] Included in Al_2O_3.
[e] Including 0.92 of sulphur.

The considerable amount of carbonate indicated both by the analyses and by the microscopic examination and the discoloration due probably to the ferrous part of that carbonate are objectionable features in the slates of Slatington, but their fine cleavage and the relative facility with which they are quarried make it possible to supply them at low figures. On the other hand they are remarkably well adapted by their softness and the thickness of the beds for mill stock and particularly for blackboards and other indoor objects.

CARBON COUNTY.

Aquashicola.—The only quarry in Carbon County is that of W. M. Bray, of Palmerton, Pa., less than one-fourth mile northeast of Aquashicola village, northeast of Lehigh Gap, and nearly 2 miles east-northeast from Palmerton station. The opening now worked is about 275 feet along the cleavage by 150 feet across and from 90 to 155 feet deep. The "top" is about 40 feet thick, of which a thickness of 17 feet is bent southward by glacial friction (creep) and is decomposed.

The beds strike N. 70° E. and dip 80° N. 20° W. The cleavage strikes N. 70°–75° E. and dips 75° S. 17° E. On the west wall, at the north side, are curved joints striking about east, spaced 3 to 6 feet. Similar joints are very abundant on the east wall. The weathered "top" is buff, as in the quarries of Lehigh and Northampton counties, and decarbonization has operated chiefly along the bedding foliation. The course of the bed is shown in places by undefined calcareous nodules weathering light brown, which in thin section show very faint aggregate polarization, much carbonate in minute particles, quartz, chlorite, pyrite spherules up to 0.03 millimeter in diameter, and fine carbonaceous matter.

The slate is very dark bluish gray. To the unaided eye it has a very fine and finely banded texture and roughish lusterless cleavage surface. It contains much carbon and a little magnetite. The sawn edge shows pyrite. The rough edge effervesces with acid test. It is sonorous and has a high grade of fissility. The ribbons do not appear to be lines of weakness.

Under the microscope this slate shows a matrix of muscovite (sericite) with fairly good aggregate polarization. The cleavage is fine, crossing the bedding at a small angle. Quartz particles (detrital) measure up to 0.02 millimeter and abundant spherules of pyrite to 0.017 millimeter in diameter. Carbonate is plentiful but not excessive. Chlorite and rutile are present. The constituents, named in descending order of abundance, appear to be muscovite, quartz, carbonate, chlorite, carbon, kaolin, pyrite, magnetite, and rutile.

This is a mica slate of the fading series.

DAUPHIN COUNTY.

Some slate cores obtained in 1908 near Derry Church, in Dauphin County, were examined, with the following results:

The slate is of dark bluish-gray color, with very fine, even, and somewhat lustrous cleavage surface. It shows pyrite on the sawn edge, is graphitic, contains no magnetite, and effervesces freely with cold dilute hydrochloric acid. It is sonorous and has a superior grade of fissility.

Under the microscope it shows fine aggregate polarization and abundant rutile needles, much carbonate in rhombs and irregular plates up to 0.06 millimeter, also abundant pyrite in spherules from 0.004 to 0.017 millimeter in diameter but mostly under 0.008 millimeter. The cleavage foliation is crossed by a fine zigzagging vein of calcite. It contains nodules of carbonate up to 0.1 by 0.04 millimeter and of chlorite up to 0.1 by 0.04 millimeter. The quartz grains measure up to 0.06 millimeter and there are a few prisms of black tourmaline.

Its constituents, named in descending order of abundance, appear to be muscovite, quartz, carbonate, pyrite, chlorite, graphite, rutile, and tourmaline.

This is a true mica slate of fine fissility but of the fading series. The cores show some variation at different depths in the abundance of carbonate veinlets and also in what appear to be "ribbons," but the general quality of the slate is the same.

YORK AND LANCASTER COUNTIES.

The slate deposit of York and Lancaster counties is known as the Peach Bottom slate. The name seems to have been derived from that of a small village one-fourth mile west of Susquehanna River, formerly a sort of a port in the now disused canal which follows the river. This village is in a triangular township of the same name, which is bounded by the Maryland line on the south, the river on the northeast, and in part by Muddy Creek on the northwest, and which forms the southeast corner of York County.

PEACH BOTTOM SLATE.

Geologic relations.—The only available geologic maps of the region are those of the two Pennsylvania geological surveys and of the Maryland Geological Survey.[1]

The slate forms a belt and low ridge from one-fifth to one-half mile wide, which extends from a point about a mile northeast of the Susquehanna, in the town of Fulton, in Lancaster County, in a southwest direction across the river and across Peach Bottom Township in York County, and continues for about 3 miles in the same direction into the town of Cardiff, in Harford County, Md. Its total length is about 10 miles, of which 1 mile lies in Lancaster County, Pa., 1½ miles is submerged by the Susquehanna, 4½ miles is in York County, Pa., and about 3 miles is in Harford County, Md. Most of the quarry population is congregated along one street, which follows the western foot of the ridge. The northeastern part of this street is Delta, Pa.; the southwestern part is Cardiff, Md.

For the literature of Peach Bottom slate the reader is referred to the writings of Rogers, Lesley, Frazer, Williams, Mathews, Merrill, and Merriman.[2]

The slate belt has on its northwest side a sericite-chlorite-quartz schist (containing rounded grains of zircon), with a foliation striking N. 45° E. and dipping 75° SE. About midway between Delta and Bryansville this schist is calcareous. According to the reports of the Second Pennsylvania Survey similar schists recur on the southeast side of the slate belt, and the whole schist formation overlies in synclinal structure the older gneisses and serpentines which occur on either side of it. These schists and the associated slate are classified as Cambrian, although no typical Cambrian fossils have as yet been found in them. A good exposure of the relations of the slate to the rocks on the southeast (referred to by Rogers) may be seen on the east side of Slate Point on the towpath along the Susquehanna. The slate here conformably underlies about 50 feet of slightly muscovitic quartzite, which was formerly quarried for canal construction, both rocks striking N. 45°-50° E. and dipping 70° SE. A little farther east this quartzite is succeeded by a coarsely plicated gneiss consisting of quartz, plagioclase, muscovite, hornblende, and epidote and having the same strike and dip. Still farther east, nearly a quarter of a mile from the contact of the slate and quartzite, slightly muscovitic quartzite about 70 feet thick crops out with a strike of N. 45°-50° E. and a dip of 42° SE. and is followed conformably by a gneiss like that previously described. These quartzites and gneisses apparently continue into Lancaster County, for in looking across the Susquehanna from Slate Point a considerable thickness of light-colored rock can be seen overlying the slates there with a steep easterly dip.[1]

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[1] Rogers, H. D., Geology of Pennsylvania, 1858. Frazer, Persifor, jr., York and Lancaster county sheets, Second Geol. Survey Pennsylvania, vol. CCC, Atlas, 1878, 1879. Mathews, E. B., Maryland Geol. Survey, vol. 2, Pl. XXX, 1898.

[2] Rogers, H. D., Geology of Pennsylvania, vol. 1, pp. 188, 189, 1858. Frazer, Persifor, jr., Geology of Lancaster County: Second Geol. Survey Pennsylvania, vol. CCC, pp. 179–190, Pls. VII, VIII, 1880. Williams, G. H., The petrography and structure of the Piedmont Plateau: Geol. Soc. America Bull., vol. 2, p. 304, 1891. Lesley, J. P., Second Geol. Survey Pennsylvania Final Rept., vol. 1, pp. 136–141, 1892. Mathews, E. B., Maryland Geol. Survey, vol. 2, pp. 215–231, 239–241, 1898. Merrill, G. P., Rocks, rock weathering, and soils, p. 229, 1897; Stones for building and decoration, 3d ed., 1903. Merriman, Mansfield, The strength and weathering qualities of roofing slates: Am. Soc. Civil Eng. Trans., vol. 27, pp. 331–349, 1892; vol. 32, pp. 529–539, 1894.

The structure of the slate belt proper is difficult to make out. The quartzite of the southeast side was not found on the northwest side during the reconnaissance. At Foulk Jones & Sons' Slate Hill quarry, 2 miles northeast of Delta, there are some indications of anticlinal structure. Apparent bedding planes dip 30°-40° SE. on the southeast side of the quarry, and similar planes curve over steeply to the northwest on the northwest side, both crossing the cleavage, which is nearly vertical. Whether this is a minor anticline in a conplex syncline or anticline or the anticlinal axis of the entire belt could not be determined. There is also danger of confounding curved joints and bedding. Frazer's section along the right bank of the Susquehanna in York County (sheet 4, vol. CCC) represents the slate as interbedded with chlorite schist and forming part of the northwest limb of a syncline several miles wide.

Characteristics.—The color of the Peach Bottom slate is very dark gray with a slightly bluish tinge. To the unaided eye it has a minutely granular crystalline texture and a slightly roughish but lustrous cleavage surface. It is markedly graphitic and contains magnetite. The sawn edges show a little pyrite. There is no effervescence in cold dilute hydrochloric acid. It is very sonorous and does not discolor.[2] Under the microscope it shows a matrix of muscovite (sericite) of rather coarse, almost schistose texture, but with brilliant aggregate polarization. There is much graphitic material in fine particles and also much quartz, some of which is probably secondary, in grains measuring up to 0.05 and some of them 0.12 by 0.03 millimeter. In some specimens chlorite can be made out mingled with the muscovite. There are tabular crystals of magnetite measuring up to 0.11 by 0.02 millimeter, and also lenses of magnetite of larger size, but the most conspicuous feature is the abundance of crystals of andalusite

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[1] See also Frazer, Persifor, jr., op. cit., pp. 133, 134.

[2] The apparent contradiction of this last statement with the passage of this slate into red clay in weathering is explained on page 53.

($Al_2O_3.SiO_2$, silicate of alumina) measuring from 0.008 by 0.001 millimeter and un
up to 0.11 by 0.03 millimeter and exceptionally 0.2 by 0.02 millimeter, and m
bering from 9 to the 310 square millimeter. These crystals contain opaque inc
sions arranged diagonally to their vertical axes, and many of them are in lenses me
uring from 0.04 to 0.25 millimeter long by 0.04 to 0.1 millimeter wide, which con
variously of chlorite interleaved with muscovite with some quartz at the ends, or mai
of quartz, the andalusite crystal having a plate of muscovite parallel to it on one
both sides; or the lens consists of muscovite, the crystal being bordered by quartz,
finally, entirely of secondary muscovite. Where not in lenses, the andalusites g
erally have a plate of muscovite on one or both sides. These crystals lie with th
long axes across the cleavage at various angles and with or across the grain, but t
axes of the lenses which inclose them are usually parallel to the cleavage. (See f
11.) Pyrite is difficult to distinguish under incident light from the andalusite wh
this is rendered opaque by inclusions. Rutile occurs in irregular crystalline mas

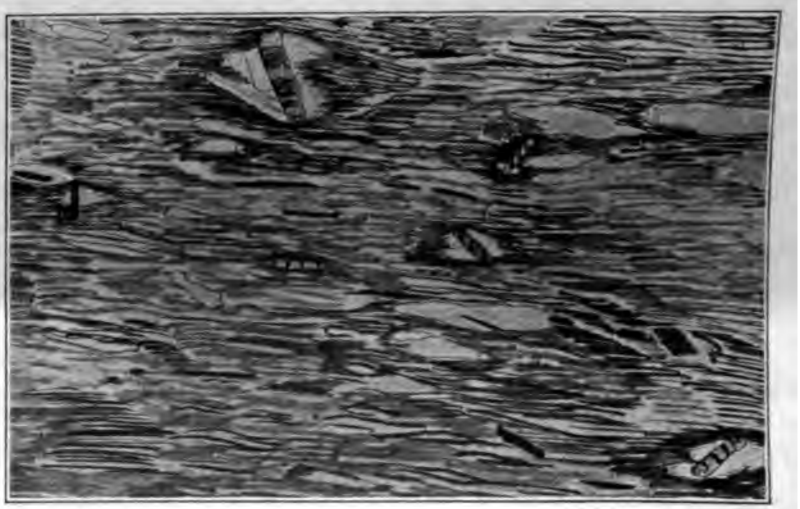

FIGURE 11.—Transverse section of Peach Bottom slate, showing andalusite crystals in a rather coars
micaceous matrix. Enlarged about 113 diameters. Some of these crystals are in lenses of quartz an
muscovite and several show inclusions.

up to 0.09 by 0.04 millimeter, but no needles were detected. There is rarely a rounde
grain of zircon; no carbonate was detected.

The important constituents of this slate, named in descending order of abundanc
appear to be muscovite, quartz, graphite, andalusite, magnetite, and pyrite, wit
accessory rutile and zircon. Figure 11 will serve to show the andalusite crystals whic
are so characteristic of this slate. The highly crystalline character of the matrix an
the absence of carbonate indicate a very durable slate.

The partly weathered slate of the "top" and "hems" shows, under the microscop
the magnetite crystals and lenses passing into hematite and the andalusite becomin
limonitic from the oxidation of its inclusions, which must, therefore, be ferruginou
and the matrix stained with hematite and limonite from the alterations.

Peach Bottom slate has been thoroughly tested by Merriman
with results as follows: Modulus of rupture in pounds to the squar
inch, 11.260; ultimate deflection in inches on supports 22 inche

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[1] Op. cit.

apart, 0.293; specific gravity, 2.894; softness (grains abraded by 50 turns of a small grindstone), 0.90; porosity (per cent of water absorbed in 24 hours), 0.224; corrodibility (per cent of weight lost in 63 hours in acid solution, consisting of 98 per cent H_2O, 1 per cent HCl, 1 per cent SO_3), 0.226.

The three published analyses show the following percentages of lime: 0.155,[1] 0.3,[2] 0.48.[3] That by the Second Pennsylvania Survey will be found in full on page 50 (analysis 7). This lime may be referable to the phosphate, apatite, which the analyses show to be present.

The Peach Bottom slate is now used almost exclusively for roofing. It also makes excellent gravestones. The chief features of this slate are stated in tabular form in the section on the comparative characteristics of slates (p. 188).

Delta and Cardiff quarries.—In 1912 seven concerns were operating quarries in the Peach Bottom slate belt. In June, 1904, there were 11. Five of these quarries or sets of quarries are located in Pennsylvania and six in Maryland. They lie in three parallel northeast-southwest lines and range from 75 to 120 feet across the cleavage and up to 200 feet in depth. The structural relations of these three belts of commercial slate are not yet apparent. The cleavage is uniformly vertical or dips steeply southeast with a strike ranging from N. 37° E. to N. 55° E. There is usually a horizontal joint—"big flat joint"—pitching gently south, locally from 40 to 60 feet below the surface and including 2 to 3 feet of crushed slate, which is evidently the result of a secondary crustal movement. Commercial slate occurs only below this joint. The "top" varies from 6 to 65 feet in thickness and in places includes 10 feet of slate in small fragments. Other flat joints dip about 20° NE. or 25° SW. Longitudinal joints strike N. 48° E. and dip 90°. Diagonal joints strike N. 25°–30° W. and also N. 45° W., dipping northeast at angles ranging from 45° to 90° or 50° to 80°. Conspicuous dip joints strike about at right angles to the cleavage and stand vertical or dip 25° or 45° SW. At Foulk Jones & Sons' quarry there are vertical diagonal joints striking N. 10° E. to N. 10° W. The grain dips 20°–50° NE. Quartz veins meander in the cleavage direction. The slate commonly has along the joint planes toward the surface a brownish rim, called a hem, from 1 to 2 inches wide and more or less parallel to the joint face. The slate breaks off at the inner side of the "hem," and this part is discarded. Some of the joints are parted and contain red clay half an inch to an inch thick. The hems represent simply the initial stage of weathering caused by the percolation of water from the joints, and of this process the final result is the red clay. The slate of the top has generally a reddish hematitic hue, and the whole belt is covered with reddish clay. The chemical processes involved in the passage of Peach Bottom slate into red clay as determined by Merrill are given on page 53. The effect of weathering, as shown under the microscope, will be discussed after the microscopic analyses of the slate.

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[1] Second Pennsylvania Geol. Survey Rept. Progress for 1877, Vol. CCC, 1880; analyses by A. S. McCreath, pp. 269, 270.

[2] Analyses by Booth, Garrett, and Blair, 1885; see Maryland Geol. Survey, vol. 2, p. 226, 1898.

[3] Merrill, G. P., Rocks, rock weathering, and soils, 1897, p. 229.

The quarrymen complain of the occurrence of what they call "black stuff," a hard material up to an inch thick, occurring locally in vertical planes diagonal to the cleavage. This material proves to be an aggregate of much pyrite, carbonaceous matter, quartz, chlorite, and muscovite, and is probably vein matter segregated from the adjacent slate.

The Baltimore Peach Bottom Slate Co., of Delta, Pa., has recently adopted the tunnel method in its Cardiff quarry in order to save the expense of removing the "top." It is found that this method also has the advantages of affording not only a shelter to the workmen but a uniform temperature of 60° both day and night and of preserving the moisture in quarried blocks for an indefinite period. The tunnel is 6 or 7 feet high, 12 feet wide, and about 600 feet long at right angles to the cleavage. It has lateral chambers, one on each side, measuring, respectively, 70 and 30 feet in length and 60 and 50 feet in width. One is 60 feet deeper than the tunnel floor; the other is 12 feet higher than its roof. Channeling and overcutting machines operated by compressed air are used.[1]

Lancaster County prospect.—Evidently belonging to the Peach Bottom slate is a deposit prospected in 1910 by P. B. Shank near Peters Creek, in Lancaster County. A specimen examined yielded these results:

The color of this slate is very dark gray, slightly bluish. The cleavage surface is fairly smooth, with minute striations in the grain direction and lustrous. The fissility is fair, grade (2). It is very sonorous. There is no effervescence with cold dilute hydrochloric acid nor any carbonate in thin section. It is very graphitic and shows no pyrite on sawn edge; there was a little magnetite in the powdered slate and in thin section.

Under the microscope it shows a matrix of muscovite (sericite), very even in grain direction, with marked aggregate polarization and containing considerable quartz and finely disseminated graphite. Its most conspicuous feature is the abundance of groups of intergrown rutile crystals (sagenite). These groups measure up to 0.04 millimeter in diameter and average about 15 to the square millimeter of thin section. A chemical analysis of the slate would probably show an unusually high percentage of TiO_2 (titanium dioxide) for a slate. There are also andalusite prisms (aluminum silicate) up to 0.066 by 0.009 millimeter, more or less darkened by inclusions and lying mostly with their long axis in the grain direction. A little tourmaline is present and probably chlorite. The constituents, named in descending order of abundance, appear to be muscovite, quartz, graphite, andalusite, rutile, chlorite (?), magnetite, tourmaline, pyrite, and zircon.

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[1] These particulars obtained through the courtesy [illegible]

This is a graphitic mica slate free from carbonate. It will not discolor and ought to prove very durable. Its cleavage appears to correspond with that of the Peach Bottom slate, which it generally resembles.

TENNESSEE.

Slate deposits occur in eastern southeastern, and northeastern Tennessee.

BLOUNT COUNTY.

The slate deposits southeast of Knoxville were described by Keith[1] in 1895 as follows:

> Two formations in this region contain beds of slate—the Wilhite and Pigeon slates. The Wilhite slate is too calcareous and soft for commercial use in the vicinity of Little Tennessee River but has the necessary hardness, evenness, and cleavage along Little Pigeon River. Along this stream the slate is well exposed over great areas but has never been developed. Quarries have been opened in the Pigeon slate along the Little Tennessee River at many points, and slates and flags taken out for local use. Recently a quarry has been opened on a small creek 2 miles from the river and much good material taken out for shipment. The slates are of fine, even grain and split into slabs an inch thick, of any desirable size, or into roofing slates. In this particular quarry the cleavage crosses the bedding and produces ribbons in much of the slate. An old quarry about 2 miles north of this shows the cleavage and bedding coincident, and flags of great size are readily loosened. Some of the slate layers contain pyrite, necessitating selection of the material for use. There are a great number of available places for quarrying in the bluffs along the river and the adjacent small streams on either side. That this slate resists weathering is amply proved by the high, sharp slate cliffs that border the river along most of its course.

The Southern Slate Co., of Columbus, Ohio, quarried a little slate near Chilhowie in 1910. There is also a slate prospect on the Virgil Grant farm, 3½ miles from Chilhowie.

The following analyses of slate quarried by the Southern Slate Co. at Maryville were made by Gilbert McCulloch, of the University of Tennessee.

Analyses of Tennessee roofing slate.

	1	2		1	2
Silica (SiO_2)	58.45	59.00	Potash (K_2O)	1.60	2.04
Alumina (Al_2O_3)	21.88	23.44	Soda (Na_2O)	2.34	1.78
Iron oxide (Fe_2O_3)	6.04	6.28	Sulphur trioxide (SO_3)	.65	.23
Lime (CaO)	1.86	1.30	Water	6.66	4.64
Magnesia (MgO)	.46	.50			

MONROE COUNTY.

Several outcrops and prospects on Tellico River and its tributaries were visited by the writer in 1912. The localities are among the western foothills of the Great Smoky Mountains at elevations between 800 and 1,000 feet above sea level and in the drainage basin of

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[1] Keith, Arthur, U. S. Geol. Survey Geol. Atlas, Knoxville folio (No. 16), p. 6, 1895.

Tennessee River.[1] According to the folios on the Cleveland quadrangle,[2] on the west, and the Nantahala quadrangle,[3] on the east, the nearest areas that have been geologically mapped by the United States Geological Survey, these slates probably belong in the Hiwassee slate (Pigeon or Wilhite slate of Hayes) and are of Cambrian age. They consist of purplish, greenish, and black mica slates, interbedded here and there with quartzite and fine conglomerate.

The openings all lie within a radius of 3 miles of Tellico Plains station, the terminal of a branch of the Louisville & Nashville Railroad, and were made by the Tellico Co., of Tellico Plains.

Falls Branch prospect.—This is 3 miles S. 5° E. of Tellico Plains station, on Falls Branch, a brook flowing northward into Laurel Creek, a tributary of Tellico River. It is on the east side of Tellico Mountain, 400 feet above Tellico Plains station and about four-fifths of a mile south of the point where the Murphy pike crosses the branch. The opening is only 10 feet square and deep. Both bedding and cleavage strike N. 55° E. and dip S. 35° E., but the dip of the bedding is 25° and that of the cleavage 50°. The thickness exposed is about 40 feet, but the total thickness may be much greater.

The slate is very dark bluish gray with a lustrous ribboned cleavage face of more or less smoothness. It does not effervesce with acid test, even when powdered. The sawn edge shows black metallic grains; the powder some magnetite and much graphite.

Under the microscope the matrix shows brilliant aggregate polarization and lenticular texture. Small ribbons cross the cleavage at an angle of 14°. These contain coarser particles of carbonate, much quartz, pyrite in particles and spherules, and here and there a plagioclase grain. The matrix has many lenses of chlorite and muscovite, mostly 0.04–0.14 millimeter, detrital quartz grains up to 0.22 millimeter, some lenses of carbonate as much as 0.14 millimeter, of pyrite up to 0.09 millimeter, and a lens of pyrite, quartz, and muscovite 0.56 millimeter. The section with the cleavage shows much carbonate in very minute rhombs and plates. Rutile is plentiful in short needles, also fine graphite, tourmaline, and zircon.

The constituents, named in descending order of abundance, appear to be muscovite, quartz, chlorite, carbonate, graphite, magnetite, pyrite, rutile, tourmaline, zircon, and plagioclase—the last two and the quartz being detrital.

This is a mica slate of the fading series, but the discoloration will probably be slight.

Lyons Creek prospect.—About 1½ miles southeast of Tellico Plains station, on the southwest side of Lyons Creek half a mile above its junction with Tellico River, is a cliff 40 to 50 feet high, of black slate, with a rusty-faced cleavage striking N. 50° E. and dipping 80° S. 40° E. Curved joints or beds in the upper part of the cliff correspond to ribbons below, which dip about 20° N. The slate crops out for 200 feet across the strike of the cleavage. About 325 feet N. 25° W. of the prospect is a bed of quartzite over 50 feet thick striking N. 50° E.

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[1] See map of Murphy quadrangle, U. S. Geol. Survey.

[2] Hayes, C. W., U. S. Geol. Survey Geol. Atlas, Cleveland folio (No. 20), 1895.

[3] Keith, Arthur, idem, Nantahala folio (No. 143), 1907.

and dipping 55° S. 40° E. The cleavage faces along the cliff are limonitic.

The slate is bluish black with more or less lustrous cleavage face. It is sonorous and does not effervesce with acid test but contains little whitish granular pyritiferous beds up to 0.1 inch thick which effervesce strongly with acid and appear to be calcareous sandstone.

Under the microscope this slate has a brilliant aggregate polarization. A 0.2-inch bed of coarser particles zigzags at right angles across the cleavage and abounds in quartz grains (mostly under 0.09 millimeter) and carbonate, has pyrite on the edges, and contains chlorite, a plagioclase, and a zircon grain. The matrix is more carbonaceous than the sandy beds and in sections with the cleavage shows lenses of pyrite to 0.5 millimeter, with secondary fibrous quartz on opposite edges, much carbon and carbonate, some tourmaline, and rutile.

The constituents, named in descending order of abundance, are muscovite, quartz, carbonate, graphite, pyrite, chlorite, plagioclase, tourmaline, zircon, and rutile. Of these, most of the quartz and all the zircon and plagioclase are detrital.

This is a mica slate with much carbonate and pyrite and will probably discolor badly.

Laurel Creek quarry.—This is but little over a mile southeast of Tellico Plains station on the southeast side of Laurel Creek about a fourth of a mile from its junction with Tellico River. The opening is 25 feet square and 50 feet deep. The cleavage, which appears to coincide very nearly with the bedding, strikes N. 35° E. and dips 55° S. 55° E. The slate is purple but incloses a bed of green 5 feet thick.

The purple (specimens D. XXXIV, 9, a–d, g) is of dark purplish-gray color and of lusterless smooth cleavage surface, in places with minute dark-green lenses. Some very delicate brownish beds and lenses up to 0.3 inch thick are calcareous, but the slate itself does not effervesce with acid test. The powdered slate effervesces strongly but shows no magnetite. Under the microscope it shows brilliant aggregate polarization and fine texture, with little beds of coarser material up to 0.37 millimeter thick crossing the cleavage at an angle of 5°. It has a very chloritic lens 0.62 millimeter thick. Minute irregular dots of very dark red hematite are scattered throughout and are coarser in the little beds, where they appear to be black and metallic. Much chlorite; no carbonate except in the little beds. The constituents, named in descending order of abundance, appear to be muscovite, quartz, chlorite, hematite, carbonate, kaolin, and rutile.

The green (specimen D. XXXIV, 9, h) is of light-blue to greenish-gray color and has a lusterless smooth cleavage surface with lenses of darker green 0.1 inch long and very thin, also brownish-weathering lenses effervescing much with acid test. The slate effervesces some, as does the powdered slate, which shows extremely little magnetite. The sawn face shows fine grayish bands and lenses. Under the microscope this slate shows a fine texture and brilliant aggregate polarization, but many lenses and beds up to 0.4 millimeter thick parallel to the cleavage containing quartz grains to 0.12 millimeter and much carbonate in a matrix of chlorite. The general matrix contains much chlorite and fine quartz but no carbonate; also oxidized pyrite and abundant slate needles. The grain is well marked. The constituents, named in descending order of abundance, appear to be muscovite, quartz, chlorite, carbonate, pyrite, magnetite, and rutile.

[illegible] mica slates. Although both contain carbonate, slates of both colors [illegible] the dumps have suffered scarcely any discoloration. The quarry was given up because of the high cost of splitting, possibly caused by the acute intersection of bedding and cleavage and the little lenses.

Tellico River prospects.—These are about half a mile east-southeast of Tellico Plains station on the north bank of the river a little east of a conspicuous road angle. The section seems to consist, beginning on the northwest, of 250 feet of slate, mostly purplish, striking N. 15°–22° E. and dipping 45° S. 70° E., underlain by a bed of slightly limonitic quartzite 25 feet thick, and that in turn underlain by 75 feet of green and purple slate, under which is still another bed of quartzite, all with the same dip and strike. The cleavage and bedding of the slate appear to be nearly identical, although the dip of the first bed of quartzite at the contact is 55°.

The purple slate (specimens D. XXXIV, 6, b, c, e) is of medium purplish-gray color and has an almost lusterless cleavage surface. It is dotted with minute lenses and contains very delicate limonitic films which do not effervesce with acid. The sawn slate shows pyrite and the powdered slate effervesces slightly and does not show magnetite. Under the microscope this has a brilliant aggregate polarization and a fine but somewhat uneven texture. There are chloritic lenses up to 0.5 millimeter thick and limonitic streaks up to 0.25 millimeter thick. The section with the cleavage shows no carbonate but dots of dark-red hematite, black metallic particles, and some pyrite, with limonite from both; rutile exceedingly minute. The constituents, named in descending order of abundance, appear to be muscovite, quartz, chlorite, hematite, kaolin, pyrite, carbonate, limonite, and rutile.

The green slate is light greenish gray and otherwise corresponds to the purple. Its color is identical with the green of the Laurel Creek quarry described above and its composition presumably not far different.

SULLIVAN COUNTY.

A slate deposit 1¼ miles south of Kingsport was visited in 1909 by C. H. Gordon, of this Survey. The following note is taken from his written report:

> The slate belongs to the Athens shale of the Ordovician[1] and is exposed along a small branch that rises on the north slope of Bays Mountain and flows into Holston River. The bedding, to judge from the relations to the underlying and overlying formations, probably dips 15°–20° S. 10° E. The cleavage strikes N. 50° E. and dips 60° S. 40° E. The two principal sets of joints, both nearly vertical, strike N. 60° E. and N. 30° W. The slate is "black," homogeneous, and even grained and effervesces with acid. In some places graptolites are very abundant. Small masses of pyrite are occasionally seen.

Thin sections of this slate, examined by the writer, yield these results:

Cleavage fair, but aggregate polarization feeble owing to incomplete micasization. Very carbonaceous; not graphitic. Carbonate very abundant; much pyrite in spherules, little quartz, rare grains of plagioclase, chlorite scales. Veinlets of calcite in the cleavage foliation.

This is not far from a clay slate, resembling somewhat that of Martinsburg, W. Va. (See p. 165.) It will probably fade badly. Its large percentage of carbonate and small content of quartz and mica make its commercial value doubtful.

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[1] U. S. Geol. Survey [illegible]

WASHINGTON COUNTY.

Specimens of "black" slate from the vicinity of Austin Springs, 4 miles north of Johnson City, and also of the Athens shale, were examined microscopically with these results:

> Better aggregate polarization than the slate near Kingsport, with much less carbonate and also more quartz. Some pyrite; carbonaceous matter probably graphite.
>
> This is a mica slate the commercial value of which will depend mainly on the uniform quality of the cleavage and the distribution of the joints. There are no data as to the structure of the deposit.

UTAH.

By Edwin C. Eckel.

For some years past a small amount of slate has been annually quarried, chiefly for samples and trial shipments, at various points in Utah. Deposits of slate, believed to be of workable extent and of good quality, have been described as occurring on the islands in Great Salt Lake, and some attempt has been made to develop these deposits.

The locality which has been most widely discussed, however, is that near Provo. This has been exploited to some extent by F. W. C. Hathenbuck, of Provo. The slate deposits occur about 2 miles southeast of Provo station, in Slate Canyon. The slate here covers a considerable area, but that exposed at the surface is so badly broken up that large slabs can not be obtained. It is possible, however, that this condition will disappear if the deposits are worked deeper.

The deposits furnish green and purple slates, the latter being apparently present in greater quantity. The green slates show little tendency to cleavage in their surface outcrops and will probably be less satisfactory for roofing than the purple. The green slates rub very smooth, however, and would make good slabs or mill stock if obtainable in masses of sufficient size.

The purple slates split well, with a surface about as smooth as that of the Peach Bottom slate of Pennsylvania and Maryland. From samples seen it appears that they also bear punching well.

A specimen of the purple slate selected by the writer was analyzed by W. T. Schaller in the laboratory of the United States Geological Survey, the results being as follows:

Analysis of purple slate from Provo, Utah.

Silica (SiO_2)	54.05
Alumina (Al_2O_3)	20.95
Iron oxides (FeO, Fe_2O_3)	.28
Lime (CaO)	.22
Magnesia (MgO)	9.12
Carbon dioxide (CO_2) Water	3.90

Of a series of 36 analyses of American roofing slates collected and discussed[1] by the writer, the above analysis of the slate from Provo stands lowest in its percentages of silica and magnesia, and its lime is very far below the average.

Nothing definite is known as to the geologic age of these slates, though they are supposed to be Ordovician, or even older.

VERMONT.

GEOGRAPHIC RELATIONS.

There are at least four distinct slate districts in Vermont. The most easterly extends along Connecticut River for more than two-thirds the length of the State. The slate is black or dark gray and has been worked in Guilford, in Windham County, at the extreme south end of the State, and also in Thetford, in Orange County, and at Waterford, in Caledonia County. The next district extends along the east flank of the Green Mountain range from the Canada line to about the middle of the State, and its slate has been extensively worked at Northfield, in Washington County. The most important district, which furnishes the well-known "green" and "purple" slates, lies between the Taconic Range and Lake Champlain, extending from the town of Sudbury, in Rutland County, southward to Rupert, in Bennington County, a distance of 26 miles. This belt also passes south-southwest into Washington County, N. Y., where, however, it has thus far proved of less economic importance. The fourth district is an area of black slate, as yet undeveloped and covering only from 2 to 3 square miles in the town of Benson, in Rutland County, near Lake Champlain.

NORTHFIELD DISTRICT.

The Vermont geologic map[2] represents a belt of clay slate, from 1 to 7 miles wide, extending from Lake Memphremagog along the east side of the Green Mountain axis as far south as Barnard, in Windsor County, a distance of 90 miles. A paper and map by Richardson[3] represent a portion of this slate belt 52 miles long, extending from North Calais, in Washington County, to a point in Windsor County nearly 10 miles west of White River Junction. The age of this slate formation was thought to be probably Devonian by the authors of the earlier report,[4] but Richardson regards it as lower Trenton. Conclusive paleontologic evidence on the subject is yet lacking.

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[1] Eckel, E. C., Jour. Geology, vol. 12, p. 26, 1904.

[2] Hitchcock, C. H., and Hager, A. D., Report on the geology of Vermont, vol. 2, Pl. I, p. 794, 1861.

[3] Richardson, C. H., The terranes of Orange County, Vt.: Vermont State Geologist Rept., new ser., vol. 3, pp. 77-79, Pls. IX, IX, *A*, 1902.

[4] Hitchcock, C. H., and Hager, A. D., op. cit., vol. 1, p. 497. 1861.

This slate has been quarried at Montpelier and Northfield, which are 10 miles apart. The strike of bedding at both places ranges from N. 10° E. to N. 25° E. At the Vermont Black Slate Co.'s lower quarry, 2 miles south of Northfield, the beds occur in minor very acute folds, which strike N. 10° E., while the cleavage, with an almost identical strike, dips 75° W. At that company's upper quarry, a quarter of a mile to the east, the beds strike N. 25° E. and dip 75° N. 65° W., and the cleavage likewise. The interpretation given by Richardson of Plate XV in his paper, referred to above, requires corroborative microscopic evidence. The low easterly (by error printed west) dipping planes resemble a secondary cleavage, and the steep westerly ones have the characteristics of bedding.

The slate continues about 300 feet west of this quarry and about a third of a mile east, making its total width in that vicinity about 2,000 feet. The general relations of this slate on the west are these: The western part contains a bed of novaculite up to 12 feet thick and is followed by slate of no commercial value, which is followed at the foot of the range, about three-fourths of a mile southwest of the village, by a sericite-chlorite-quartz schist containing grains of plagioclase, with a vertical slip cleavage striking about north and a plicated bedding having a northerly pitch. Beyond a covered interval, at a point on the range 2 miles west of the village, there is a large exposure of thin-bedded, more or less muscovitic quartzite, containing grains of zircon and plagioclase, so intricately folded as to strike N. 20° E., N. 20° W., N. 50° E., and due east. An area of a few acres of muscovite granite (formerly quarried, Moses King property) lies within this quartzite, or at least with this quartzite on both its east and west sides.

In 1904 but one quarry was in operation in Northfield Township, that of the Vermont Black Slate Co., which then measured about 100 feet along the strike, 60 feet across it, and 55 feet in depth. The company later reopened the "Clark quarry," on the ridge, a quarter of a mile east and 100 feet above the first. In 1909 both quarries became idle, and they were still idle in 1912. The Clark quarry has an east-west working face 100 feet long and 35 feet high and the beginning of a north-south face.

At the lower of these quarries the cleavage strikes N. 12° E. and dips 75° W. There are three sets of joints—(*a*) striking N. 15° E., dipping 50° N. 75° W.; (*b*) striking N. 77° W., dipping nearly 90°; 90°; (*c*) striking N. 55° E., dipping 65° N. 35° W. The grain dips 70° N. An exceptional slip cleavage dips 15°-20° N.

At the Clark quarry the cleavage and beds strike N. 25° E. and dip 75° N. 65° W. Slip cleavage, which is confined to certain beds and to certain horizontal zones, strikes N. 60° E. and dips 15° N. 30° W. A quartz vein half an inch thick cuts the beds from east to

side of Lake Bomoseen purple slate nearly 100 feet thick is exposed. The purple slate in places contains a few inches of dark-reddish slate not unlike the red of the Ordovician. There is some difference in the shade of the different beds of green in the same quarry, some being more greenish, others more grayish. There are also differences in the amount of discoloration produced by weathering in beds of the same locality. Although some quarries produce only the so-called "unfading green" and others only the "sea-green," these differences appear to occur not in strata of different ages but at different points in strata of the same age.

Interbedded with the slates are strata of calcareous quartzite ranging in thickness from a few inches up to 5 feet. This quartzite contains a few grains of plagioclase and more muscovite scales and is veined with quartz, which crystallizes in cavities. Here and there the quartzite weathers brown; its calcite, therefore, probably contains some siderite.

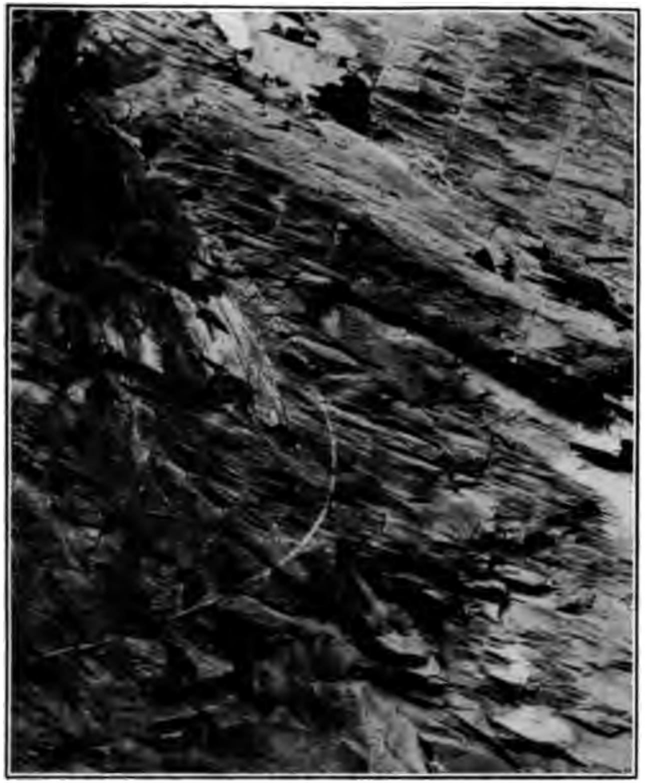
Associated with the slates are also beds of limestone conglomerate or breccia ranging from a few feet to 40 feet in thickness, carrying the trilobite Olenellus and other fossils characteristic of the Lower Cambrian. One of these beds of limestone breccia is of common occurrence in the quarries, overlying the slate. (See quarry diagram *P*, Pl. XXIV.)

The slate-bed surfaces are generally covered with annelid trails or impressions of algæ, or both. Many of the purple slates are ribboned or banded with light-green slate beds an inch or more in thickness or have oval or roundish light-green spots, frequently in rows. Similarly the "sea-green" slates are crossed by grayish ribbons.

The position of these commercial slates in the Lower Cambrian series is shown in the following table, in which the beds are arranged in their natural order:

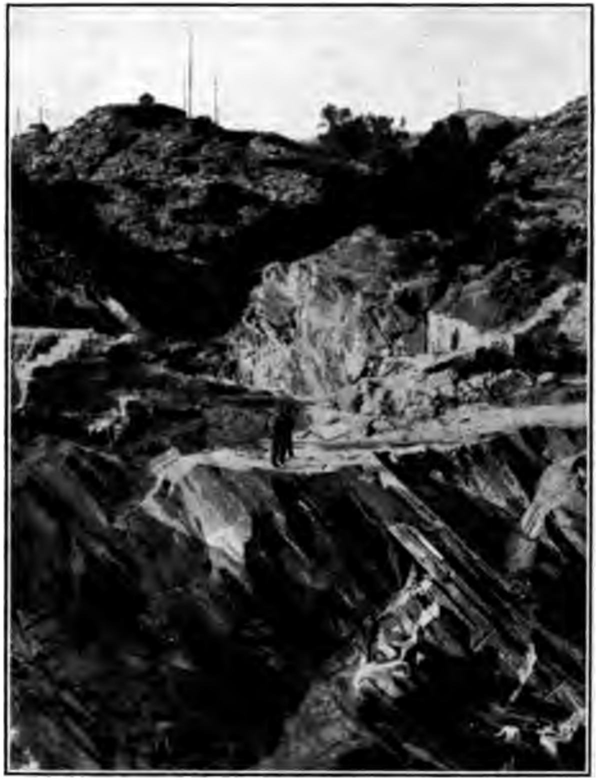
Lower Cambrian rocks of slate belt of western Vermont.

	Feet.
E. Ferruginous quartzite and sandstone	25–100
D. Black shale and slate with Lower Cambrian fossils	50–250
C. Black patch grit; a dark-gray grit or sandstone with black shaly patches, locally with calcareous nodules carrying Lower Cambrian fossils	10– 40
B. Roofing slate, grayish green, purplish or mixed green and purplish, alternating with beds of calcareous quartzite and of limestone breccia up to 40 feet thick, the breccia carrying Lower Cambrian fossils	200–240
A. Olive-colored grit or graywacke, more or less massive, with minute scales of hematite or graphite, containing some small quartzite beds, much of it calcareous, generally weathering a pale brick-red. Under the microscope shows grains of quartz, feldspar, and large scales of muscovite and of chlorite interleaved with muscovite. Associated with this is a bed of quartzite 12 to 55 feet thick	50–200



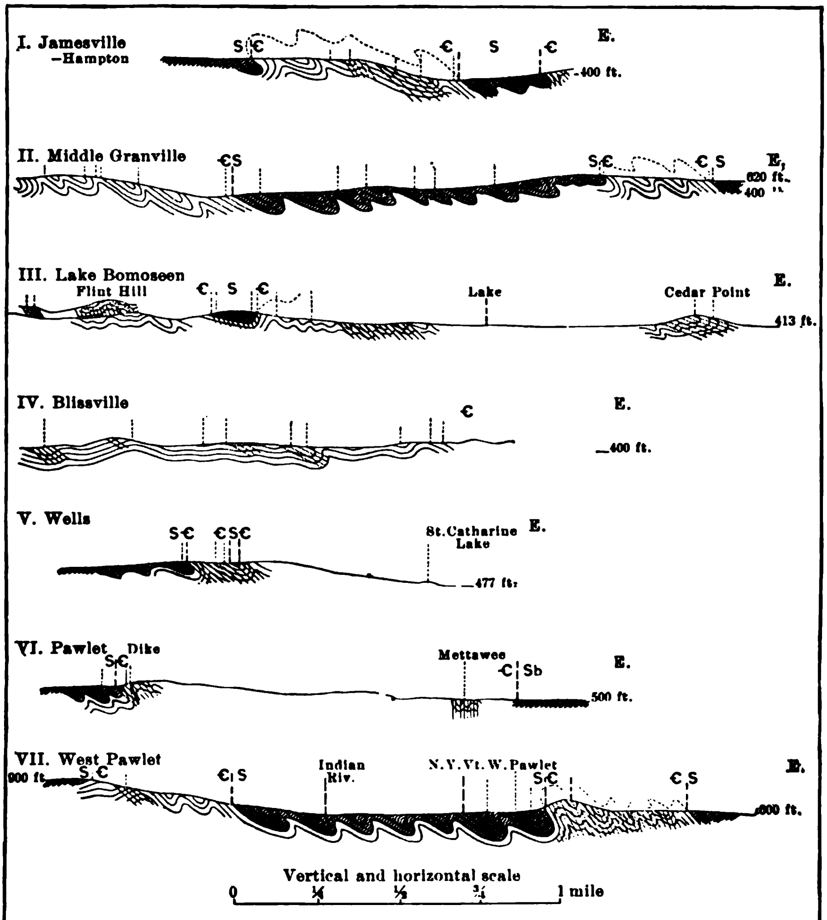
A. CEDAR POINT QUARRY, ON LAKE BOMOSEEN, CASTLETON, VT.

North face, showing good mill-stock slate in cross fracture. The flat syncline has a slight southerly pitch and the cleavage dips 15°-20° E. The board on the wall is 3½ feet long. Compare Plate XXIV, N.



B. CLAY QUARRY, PAWLET, VT.

North face, showing, in cross fracture, about 50 feet of good roofing slate, with bedding and cleavage parallel. The four men in a group are standing upon a freshly exposed glaciated surface. At the left is a 10-foot remnant of thin-bedded horizontal postglacial clay, from which the quarry is named



LEGEND

Section lines on Quarry maps, Pls. XX and XXI.

Vertical dotted lines indicate places where dip was observed; otherwise hypothetical.

Vertical dashes indicate boundaries between Cambrian and Silurian, or refer to names.

▨ = Ordovician (Lower Silurian) shales, grits, and red and green slate.

All other areas = Lower Cambrian shale, limestone, quartzite, and green and purple slate.

SECTIONS ACROSS THE NEW YORK AND VERMONT SLATE BELT.

The base of the formation is not certainly exposed. There may be a bed of commercial slate in the olive-colored grit.

The probable structure and structural relations of the two slate formations of western Vermont are shown in Plate XXII. Each section is described beyond in detail. Those parts of the sections which are well substantiated are indicated by vertical dotted lines. The typical features of the region are finely shown at certain points, and these have been utilized in drawing the hypothetical parts of the sections. Symbols showing the structure at a number of the quarries are given on the large-scale quarry maps (Pls. XX and XXI), on which the section lines have been drawn.

GEOLOGIC SECTIONS.

SECTION I. JAMESVILLE-HAMPTON.

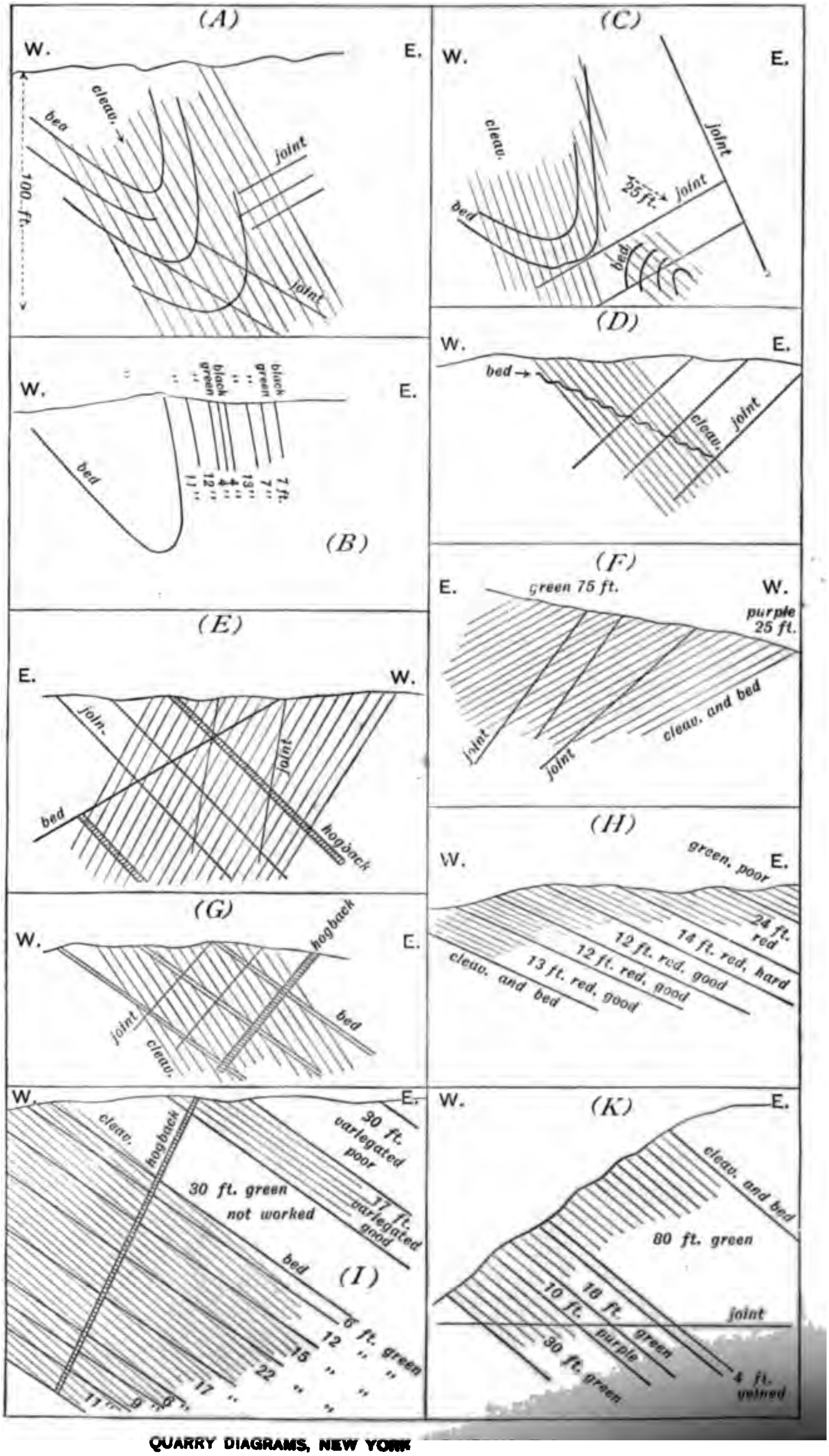
Section I crosses the Jamesville Cambrian slate belt. The occurrence of the Ordovician red slate on the east of the Jamesville belt is shown at the Matthews quarries, a mile west of Poultney, in Hampton, and on the west at those of the National Red Slate Co., about a mile north-northwest of Raceville, in the town of Granville. About a mile due north of Raceville there is a small opening in red slate in close proximity to the Cambrian. The red slate dips easterly under the Cambrian by overturn. From 500 to 600 feet north-northwest of this opening the Ordovician grits crop out, and a mile north-northwest, on the east side, three-fourths of a mile north of the section, Mr. Walcott found Ordovician graptolites in eastward-dipping shales.

The eastern base of the Jamesville Ridge consists of the Cambrian black slates and shales with small beds of limestone (D in section on p. 124). These also crop out at the bend in the road south of the section. These slates and shales form the uppermost strata of the ridge, the quartzite and sandstone (E) being absent, but that outcrop probably belongs to those on the west side of the ridge. Arising from beneath the black slates and shales are the green and purple roofing slates (B), with 10 feet of limestone carrying Lower Cambrian fossils. There are seven or eight old quarries on the hillside. In the largest one 20 feet or more of black and gray slates overlie the green and purple slates, which dip 22° E., with a cleavage of 35° E. A low easterly bedding and a steeper easterly cleavage (up to 45°) are well shown at several quarries. Beds of calcareous quartzite occur. The purple slates here underlie, not overlie, the green. In the main the ridge appears to be an anticline of the roofing slates (B) and the black slates (D), very much overturned to the west, with the red slates and the Ordovician graptolite shales and Ordovician grits on both sides of it. In Section I the only well-observed features are the relations of cleavage and bedding on the eastern slope. The overturn at the

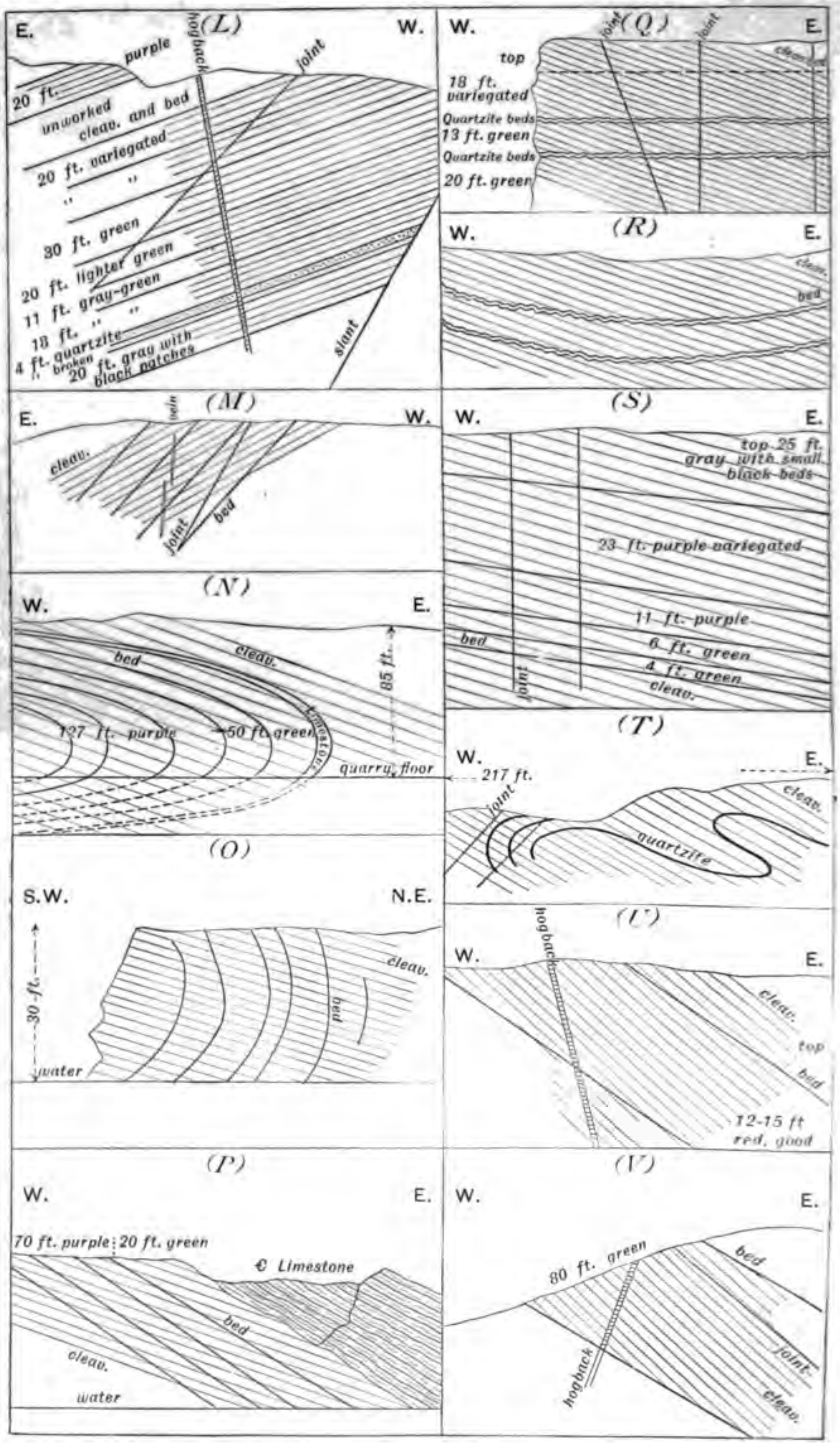
PLATE XXIII.

Structural Diagrams of Slate Quarries in Eastern New York and Western Vermont.

A. Rising & Nelson's "sea-green" quarry No. 2, West Pawlet, Vt.
B. Rising & Nelson's "sea-green" quarry No. 2, West Pawlet, Vt., with measurements.
C. Hughes's "sea-green" quarry No. 7, West Pawlet, Vt.
D. Roberts R. Roberts's "sea-green" quarry, Pawlet, Vt.
E. Hughes's western quarry "sea-green," Pawlet, Vt.
F. McCarty's "sea-green" and purple quarry, Poultney, Vt.
G. Schmidt & Williams's "sea-green" quarry, Pawlet, Vt.
H. Empire slate quarry (red), Granville, N. Y.
I. Auld & Conger's quarry ("sea-green" and variegated), Wells, Vt.
K. Griffith & Nathaniel's quarry ("sea-green" and purple), Poultney, Vt.



QUARRY DIAGRAMS, NEW YORK



QUARRY DIAGRAMS, NEW YORK AND VERMONT SLATE BELT.

PLATE XXIV.

STRUCTURAL DIAGRAMS OF SLATE QUARRIES IN EASTERN NEW YORK AND WESTERN VERMONT.

L. Eureka slate quarries ("unfading green" and variegated), Poultney, Vt.
M. Valley Slate Co. ("unfading green"), Poultney, Vt.
N. Lake Bomoseen Slate Co. (mill stock, purple and green), Cedar Point, Castleton, Vt.
O. Old quarry (purple with green ribbons), near Blissville, Castleton, Vt.
P. Old quarry near and north of Eagle quarry, purple with green ribbons, Blissville, Castleton, Vt.
Q. Meadow Slate Co.'s quarry (mill stock, variegated and green), Fair Haven, Vt. Calcareous quartzite beds 4 to 12 inches thick and 18 inches apart.
R. Meadow Slate Co.'s quarry, Fair Haven, Vt., at north end.
S. Scotch Hill Slate Quarry Co.'s quarry (mill stock, purple, variegated, and green), Fair Haven, Vt. Dark beds are said to underlie the green.
T. Old quarry (purple), 1 mile south of West Castleton, Vt.
U. National Red Slate Co.'s quarry, southwest of Jamesville, in Granville, N. Y.
V. Williams & Edwards's quarry ("sea-green"), Wells, Vt.

west where the Ordovician underlies is inferential, and the other folds are hypothetical.

SECTION II. MIDDLE GRANVILLE.

Section II crosses the Middle Granville "sea-green" and red-slate quarries. Judging from the dovetailing of the Cambrian and Ordovician a few miles south of Middle Granville, we should expect, immediately west of Middle Granville, first, an anticline, then a syncline. The Jamesville belt crossed by the east end of the section would be, as in Section I, anticlinal, and the intervening broad Ordovician belt would be synclinal in structure.

There are about a dozen Cambrian slate quarries north of the village. Some measurements were taken about these quarries by the writer, but the locality is perplexing. There is a fault, and possibly much folding and faulting. The following succession, however, is clear, beginning above: Black shale and slaty shale (D), 70–100 feet; limestone with Lower Cambrian fossils, 4 feet; green and purple slate (B), 50–60 feet. An open drainage cut 213 feet long, east of one of the larger quarries, crosses the black shales and exposes one fault plane. There is a tunnel 180 feet long west of the quarry, with a shaft at the end in black shales, and the men who worked in the tunnel report that it also traversed black shales. West of the shaft is another slate quarry, and southeast of the east end of the open cut still another. There appear, therefore, to be two masses of black beds and three of roofing slate. Mr. Prindle finds some evidence of an Ordovician area at the top of the hill. It would seem possible that between that point and the red slate of the valley on the east there is an anticline consisting of several minor folds, and that the Cambrian green and purple slate occupy the centers of the lesser anticlines and the black shales the sides, as shown in the section. But the structure might be interpreted as consisting of two beds of green and purple slates alternating with two of black shale, or a fault could be supposed between the central body of green slate and the black slate west of it. Several quarrics in this line show about 70 feet of the black rock (D).

Only scattered observations were made in the valley east of the ridge, and these all indicate low easterly dips, and so do most of the observations at Nixon's and Pritchard's quarries, there being slight indications of a .westerly dip at one of the latter. The folds are probably all overturned to the west, but their dimensions may vary greatly from those shown in this part of the section. The only data as to the Cambrian ridge at the east end of the section are easterly dips on both its east and west sides, indicating the usual overturn.

SECTION III. LAKE BOMOSEEN.

Section III crosses Cedar Point and extends to Glen Lake. At the Lake Bomoseen Slate Co.'s quarry, Cedar Point, purple slate 127 feet thick is overlain by 50 feet of green slate, and this, in turn, by 5 to 10 feet of limestone, but all doubled over into a close syncline with an axial plane almost if not quite horizontal and traversed by a cleavage foliation dipping 20° E. (See Pl. XXIV, *N*.) For that part of the section which lies east of the Ordovician strip and west of the bend in the section line the data have been taken from the old quarries a mile south. (See Pl. XXIV, *T*, and Pl. XXII.) The folds are many and small and overturned to the west. At the West Castleton quarries, north and south of this section and east of the Ordovician strip, the slates dip 45°–50° E., and consist of about 25 feet of purple slate overlain by 8 feet of green slate and 8 feet of limestone, followed by poor slates and quartzite beds. The relations of the Ordovician and Cambrian rocks are not well exposed. The Cambrian slates must either turn steeply to the west or be faulted. At the extreme north end of the Ordovician strip Mr. Prindle made out the following relations: The black Cambrian slates (D, p. 124) and the ferruginous quartzite (E) occur between the Cambrian limestone and roofing slates (B) and the Ordovician graptolite shales. About half a mile north of West Castleton the graptolite shales occur 300 feet west of the Cambrian slates, with some thin quartzites.

The structure of the Ordovician strip itself is beautifully shown at a ledge by the roadside between West Castleton and Glen Lake. (See Pl. III.) The rock is a grayish, more or less calcareous shaly or arenaceous slate, banded with black beds from a fraction of an inch to 2 inches in width. On the west side of the syncline the beds dip very slightly east or are horizontal. Farther east, at the top, the dip is 55° W., and still farther east it is 90°. The cleavage throughout is about 35° E. The ledge is evidently the center of the syncline and gives the key to the structure of the whole strip, which is 3¼ miles in length, while the fossils leave no doubt as to its age.

SECTION IV. BLISSVILLE.

Section IV crosses several lines of quarries near Blissville, in Castleton, Vt. There are 20 quarries hereabouts, including the old Eagle quarry. The northeasterly line of quarries shows a minimum of about 50 feet of green and variegated slate (strike N. 10°–15° E., dip 20°–30° E.), overlain by 20 feet of black slate and shale and thin-bedded limestone (D, p. 124), a few feet of green slate, and a bed of quartzite 10 to 12 feet thick (E), which is exposed for 350 feet along the strike. The quartzite contains calcareous nodules which weather out. It overlies and, at the south, runs into a few feet of a green grit like that of Flint Hill. The black shales crop out at several points along the road south, and also on the ridge east of it.

Between this line of quarries and the road running south the olive-colored grits (A) crop out at several points and extend to the road corner north—all with an easterly dip. The first quarry on the west side of the north-south road shows a very gentle syncline at its south end and the beginning of an anticline at its northeast corner. The next line of quarries to the west includes the Eagle. The strike here changes to N. 15°–40° W. The dips are 25°–30° E. and SE. The cleavage strikes N. 5° E. and dips 20° E. The beds include about 70 feet of purple slate, overlain by 10 feet of green slate and 15 feet of thin-bedded Olenellus-bearing limestone. At the most northerly quarry but one of this line the beds are folded and overturned almost as much as at Cedar Point. (See Pl. XXIV, *O*.) The strike of the axis of the fold is N. 40° W.; the cleavage dips at a low angle to the east. Small beds of light-green slate, with or without a quartzose limestone in the center, produce bands on the cleavage surface.

At a quarry intermediate between the second and third lines of quarries, one-fourth of a mile north of this section, the strike changes to N. 75° W., dip 15°–20° S., and the cleavage strike to N. 35°–50° E., dip 15° E. The complication is probably due to a southerly pitch.

In the third line of quarries the beds are nearly horizontal. The fourth line, half a mile south of the section, shows very low westerly dips, and at the extreme west end of the section a gentle syncline is exposed crossed by a cleavage dipping 35° E.

SECTION V. WELLS.

Section V starts at the west shore of Lake St. Catherine and crosses the slate ridge to the west.

The portion of the slate belt most largely worked of late years is the ridge between West Pawlet and Poultney. Away from the quarries it is difficult to obtain satisfactory observations, and within the quarries bedding is generally obscured by cleavage.

Beginning at the lake, purple and green Cambrian slates dip 45° E. To judge from scattering observations along the west side of the ridge, it must be composed largely of roofing slate. From a point about half a mile west of the lake there is a line of quarries and prospect holes extending northward for 2 miles. The cleavage dip is uniformly east. Farther west the section crosses a strip of red Ordovician slate almost half a mile long and 18[illegible] wide at the broadest part but tapering out both north and [illegible] The dip is

35° E. This is probably a small compressed and overturned syncline. The Ordovician grit is absent here, but some of the small quartzite beds occur between the Cambrian slates and the red slates. All the slates exposed between the strip of red and the road on the west should recur on the east of the red slate, but in inverse order. At Auld & Conger's quarries 170 feet of slates of various qualities, green and variegated, are exposed. The strike here is N. 5° W. and the dip 35° E.; the cleavage dips 40°–45° E. Dipping toward and under the slate, but with greenish and grayish beds intervening, are the Ordovician grits, which strike N. 5° E. and dip 40° E. Between the syncline of red slate and the Ordovician grits there is probably an anticline, as drawn in the section, and all the slates on the west side of the red ought to recur east of the grits in inverse order. The folds in the grit shown in the section are hypothetical, but the first one west of the slate would naturally be a syncline.

SECTION VI. PAWLET.

Section VI begins near Mettawee River and crosses the slate ridge. The boundary between Ordovician and Cambrian at the east end of the section is uncertain. In the gorge of the Mettawee green and purple Cambrian slates of no commercial value are finely exposed. At the sawmill the axial planes of the folds stand erect and the anticlinal parts of some of the folds have been pinched out. The cleavage is vertical. The east side of the ridge for a mile and more to the south consists of folded schists interbedded with quartzite, possibly belonging to A of the section on page 124. West of this is a strip three-fourths of a mile wide of unknown character, but from the situation of two quarries about 2¼ miles south of a point half a mile west of the Mettawee sawmill, and from the direction of the strike of the slate at these quarries, slate probably occurs in the western half of this blank space of the section. The roofing-slate quarries from this latitude to West Pawlet lie almost all within a strip one-fourth of a mile wide along the east side of the Ordovician grits on the western slope of the ridge. The structure at the quarries is difficult to make out. Bedding, where observed, dips east, as does also the cleavage. From the observed relations of the Cambrian and Ordovician wherever they occur very near each other in this region, the Cambrian overlies the Ordovician through an overturn. An anticline should therefore occur on the Cambrian side of the boundary and a syncline on the Ordovician side of it. Not far from the Columbia quarry is a dike of camptonite, 5 feet 9 inches wide, running northeast and dipping 90° or steeply to the northwest. The slate on the east side of the dike strikes north and dips 70° E. and that on the west side dips 55° E. The dike has a rough jointing parallel to its sides and weathers in spherical nodules. The cleavage at the quarries dips about 55° E. West of the quarries are greenish shales and schists with small quartzite beds striking N. 5° E. and dipping 45°–50° E., measuring, apparently, about 125 feet, but possibly less, if closely folded. These beds probably belong in the Ordovician. West of them come the Ordovician grits, dipping 65° E.

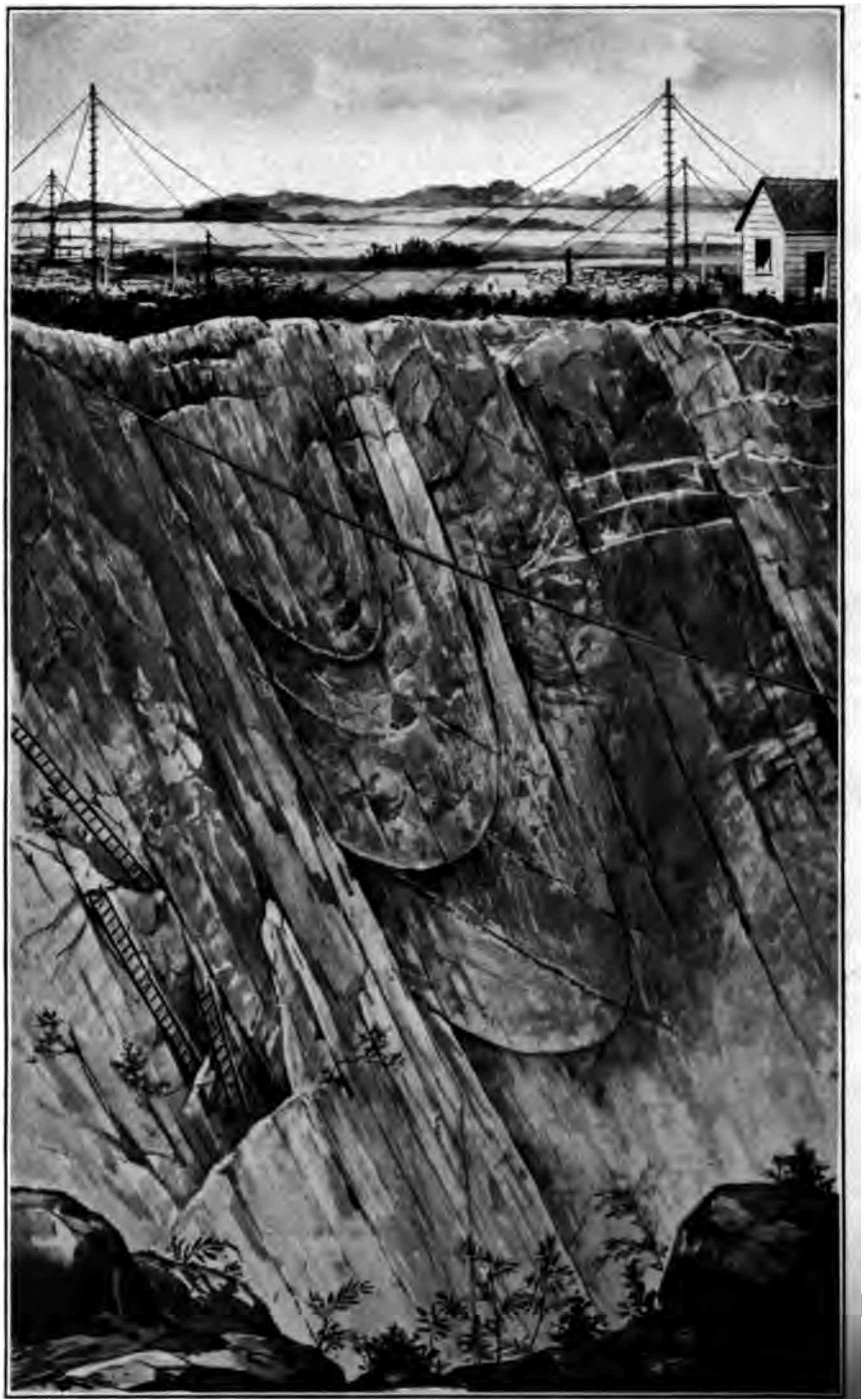
SECTION VII. WEST PAWLET.

Section VII crosses the West Pawlet quarries and reaches the other Cambrian belt west of Indian River. The West Pawlet belt ends abruptly south of the village, with Ordovician grits south, east, and west.

Some of the quarries are more than 175 feet in depth. At the Hughes quarry No. 7 there is a syncline with an anticline east of it (see Pl. XXIII, *C*), and the foreman stated to the writer that another one was found later east of it. The pinching out of the material between the folds observed at the Mettawee gorge recurs here. At the Rising & Nelson quarry No. 2 the syncline is finely shown (Pl. XXV and Pl. XXIII, *A*). We have here an isoclinal syncline with its axial plane dipping east with the cleavage. In such a structure the same beds of course occur on each side of the fold in opposite order and also at the bottom, but there they are thicker. The structure indicated is a syncline with an anticline on each side of it, but unless faulting occurred these must be parts of an anticline, and the Ordovician grits, which crop out in the village and at the foot of the dumps, should be part of a syncline. The strike of the slates ranges from N. 12° E. to N. 25° E., and that of the cleavage from N. 5° W. to N. 5° E., the dip is generally 70°, but in places 40°–50° E. The thickness exposed, measured across two synclines and one anticline, is about 100 feet. There are on the east side of the syncline some dark-gray or "black" beds which, according to this construction, would belong not on top, but within the roofing slates (B, p. 124). The Ordovician grits west of the Cambrian slates strike N. 10°–20° E. and dip 55°–60° E., but at the West Pawlet railroad station the strike changes to N. 5° W. and the dip to 80° E.

In the Indian River valley neither the few red-slate quarries nor the scattering outcrops afford very satisfactory data. The folds are probably numerous and overturned so as to give only easterly dips. Mr. Walcott has indicated a graptolite locality on the west side of the valley.

The Cambrian ridge at the west has a few old purple-slate quarries. Some Cambrian fossils occur in the limestone. Along the east side of the ridge lie the Cambrian shales (D). About half a mile east of South Granville, near the Ordovician boundary, west of this Cambrian belt, the purple slates dip 40° W. and have a cleavage



SLATE SYNCLINE, WEST PAWLET, VT.

North face of Rising & Nelson's "sea-green" slate quarry No. 2, showing

Depth, 100 feet to lower syncline.

dipping 30° E. and striking N. 15° E., the bedding forming green bands on the cleavage surfaces. The second Cambrian ridge is clearly anticlinal in structure.

GENERAL STRUCTURAL FEATURES.

From the sections above described, necessarily more or less incomplete, the general structural characteristics of the western Vermont and eastern New York slate belt can be grasped. The structure of the Cambrian slate mass, which usually adjoins the Ordovician schist, is illustrated in sections VI and VII. It lies in close folds, more or less overturned to the west, with eastward-dipping slaty cleavage obscuring the bedding. The folds are so close and the cleavage is so pronounced that the cores of adjoining synclines and anticlines are brought very near together, or the anticlinal portions of several adjacent folds do not appear. In the northern part of the Cambrian area quartzite beds within the roofing slates are more abundant than in the southern part. Although the entire mass of slate and quartzite is in places thrown into folds so greatly overturned that their axial planes are nearly horizontal, yet the slate itself is less distorted in the direction of the cleavage and the cleavage itself is also less perfect in the northern than in the southern area. Series of such various folds form compound anticlines, and these minor Cambrian anticlinoria alternate with Ordovician synclinoria overlying Cambrian ones in apparent but not real conformity. As the Ordovician areas consist of shales, slates, grits, and small quartzite beds, the beds are more heterogeneous and slaty cleavage is less prevalent, but the folds are also overturned toward the west. (See Sections I, II, V, VI, VII, Pl. XXII.)

A north-northwesterly strike appears in the Cambrian rocks about Blissville and again at Cedar Point. (See map, Pl. XX.) Large beds of quartzite overlie the roofing slate and are typical of this portion (Section III, Pl. XXII).

The slate folds have suffered much erosion (Pls. III, XXV). The surfaces when freshly exposed are finely striated and in places deeply grooved by glacial action. The glaciated edges are covered either by morainal deposits or by finely bedded clays dating back to the postglacial submergence. (See Pl. XIX, *B*.)

GEOLOGIC AND GEOGRAPHIC DISTRIBUTION.

The quarry maps (Pls. XX and XXI), show that the slate quarries situated within the Cambrian areas are generally very near to or not far from the edge of the Ordovician belts. In some places (as in [illegible] Wells, and West Castleton) the Cambrian slates occur within [illegible] of the Ordovician grits. This proximity of the two formations occurs in such a variety of situations that it can hardly be explained by faulting. The Cambrian roofing slates are therefore regarded as occurring not far from the top of the Lower Cambrian series as exposed in this region and very near the overlying Ordovician. As the Cambrian belts are made up of numerous folds generally close and overturned, the slates also occur toward the center of the belts, but their stratigraphic position is still the same. The first place to look for the Cambrian roofing slates is near the Cambrian-Ordovician boundary. Where the red slate occurs in close proximity to and on the west side of the Cambrian green and purple slates and the dip is easterly, as it usually is, the red slate may be found underlying the "sea-green," "unfading green," or purple slates, and on the east side of the Cambrian areas the green and purple slates of the Cambrian may be found underlying the red of the Ordovician when both dip easterly. At several points (Blissville, Eureka, etc.) away from the Ordovician boundary the rock which appears to immediately underlie the Cambrian slates is the olive-colored grit (A, p. 124), one of the so-called "wild rocks" of the quarrymen. It is uncertain whether there may not be one or more beds of slate interbedded with this. The rock which overlies the Cambrian slate is either the "black patch" grit (C) or the Cambrian black shale (D) or the ferruginous quartzite and sandstone (E). Perhaps most generally there is a bed of limestone conglomerate or breccia, followed by black shales or slates (D). (See p. 124). These vertical relations are pretty well established.

The areal relations of the "sea-green" and the "unfading green" are not at all clear. Nothing has yet been found to show that the stratigraphic position of these two varieties of Cambrian slates is not identical. It seems probable that, at the latitude of a point within 2 miles north of Poultney, a change in the sediments occurred in Cambrian time sufficient to account for the diminished percentage of carbonate and the increase of chlorite and pyrite. Whether this difference in composition is alone sufficient to account for the difference in the cleavage is uncertain. There may have been some difference in the resistance to pressure which would account for more perfect cleavage at the south than at the north. Possibly, as has already been suggested, the greater abundance of grains of quartz at the north may have restrained the cleavage structure, and so with more lime deposited at the south and more quartz sand at the north the whole structural difference may be traced back to changes in sedimentation.

Even this demarcation between the areas of "fading" and "unfading" green slate is not absolute, for "fading green" slates occur well within the "unfading green" area, as at an old quarry 1½ miles southwest of West Castleton a half a mile south of Bomoseen. Slates which fade little are reported as occurring on the ridge west of Lake St. Catherine. In an old quarry about half a mile east of Jamesville, in a belt that seems to be directly continuous with that in which lies the Eureka and adjacent quarries, the slates fade comparatively little. In the Jamesville belt, at a quarry about 180 feet above the road and west of the chapel, there is a purple bed, probably overlying a green one; both purple and green fade badly, but on the west side of the purple—that is, underlying it—is a green bed which scarcely fades and which, under the microscope, shows very few carbonate rhombs.

The "sea-green" slate at two newly opened quarries in Bullfrog Hollow, in Wells, 2½ miles east-northeast of Middle Granville, has less carbonate than many slates of that belt, but it fades. Some old quarries reopened in 1911 in the "unfading green" belt in Fair Haven, near Carvers Falls, contain even less carbonate than that of the same sort in Poultney. The most southerly outcrop of the "unfading green" observed by the writer occurs 2½ miles N. 25° E. of Poultney and three-fourths of a mile east of the railroad.

A few things should be noted. The continuation of the slate of West Pawlet is to be looked for in the lenticular Cambrian area which begins 2 miles south of West Pawlet and stretches across the New York State line into Hebron. "Sea-green" and purple slates also occur in the Cambrian area southeast of West Pawlet. The Jamesville belt continues south into the village of Granville. About the north end of Lake St. Catherine the Cambrian slate belt divides in two, one part passing half a mile east of Poultney and the other half a mile east of East Poultney, where it crops out in the small gorge of Poultney River. In many places north of Castleton the strikes change to the northwest or the north-northwest, and the beds of slate locally follow this direction. Barker Hill and Wallace Ledge both have Cambrian slates about them.

QUARRY STRUCTURE.

The types of structure exposed at the quarries are shown in diagrams *A–G*, *K–T*, and *V*, on Plates XXIII and XXIV, and also in Plates XIX, *A*, and XXV.

The table on pages 137–138 contains the more important compass observations taken at the quarries. The numbers in the first column will be found on the maps, Plates XX and XXI. Where cleavage is given but not bedding, the bedding is very nearly or quite the same as the cleavage. The usual dip joints may be assumed where not given. Approximations are indicated by the signs plus (+), minus (−), more or less (±). Close jointing in the dip direction occurs in places. Such joints are spaced 4 to 24 inches over a length of 200 feet on the west wall of the Norton No. 6 quarry in Pawlet.

To the data given in the table should be added a few observations at quarries outside of the areas shown on the maps. An abandoned quarry three-fourths of a mile south of Fair Haven shows 24 feet of purple slate overlain by about 9 feet of greenish slate, dipping 15°–20° E. and containing three beds of quartzite, each 2 inches thick. The cleavage strikes N. 10° W. and dips 25°–30° E. Joints strike N. 35° E., dip 60° E.; also N. 50° E., dip 90°. There is a fatal secondary cleavage—"false cleavage"—here, striking about north. (See Pl. VII, *A*, and p. 37.) At the Meadow Slate Co.'s quarry (Pl. XXIV, *Q*, *R*), and at the quarry just north of it the bedding strikes N. 15° E. and the cleavage strikes N. 7°–15° W., and dips 15°–20° E. Vertical strike joints strike N. 15° E. and vertical dip joints N. 85° W. Diagonal joints strike northwest, dip 65° NE.; also N. 58° E., dip 90°. The grain strikes N. 35° W. At the Scotch Hill quarries (Pl. XXIV, *S*), 2 miles north-northeast of Fair Haven, the beds strike N. 25° W. and dip 5° E., and the cleavage has the same strike and dips 15° E. The joints are vertical, striking N. 5°–17° E. and N. 67° W.

At the Hampshire Slate Co.'s quarries, about one-third of a mile east-southeast of Carvers Falls, in Fair Haven, the beds strike N. 15° E. and dip 33° S. 75° E., but the cleavage strikes north and dips 40° E. At the Cedar Point quarry (No. 43, Pl. XXI) there is a marked southerly pitch, the syncline being found to rise as quarrying proceeds northward. There is also here a slip cleavage parallel to the axis of the fold, which prevents the slate from being used for roofing but does not interfere with its use for mill stock. On the hill north of the quarry this slip cleavage is vertical. At the now disused quarries 4 miles southwest of Brandon, in Sudbury, the beds strike N. 55° E. and dip 35° S. 35° E., and the cleavage is in places parallel, but some adjoining slate ledges have a slip cleavage that strikes N. 25° W., with the neighboring Ordovician schists.

Slate-quarry observations in Vermont.

Quarry No. on Pl. XX or XXI.	Bedding.		Cleavage.		Strike joints.		Dip joints.		Diagonal joints.		Grain strike.	Shear zones ("hog-backs").		Faults.	
	Strike.	Dip.	Strike.	Dip.	Strike.	Dip.	Strike.	Dip.	Strike.	Dip.		Strike.	Dip.	Strike.	Dip.
10........	N.+	30° E.	N.	42° E.	N. 5° W..	40° E.	....	....	....	....	....	N. 37° E.	65° NW.	....	....
[illegible]	N. 5° E.	40° E.	N.	40° E.	N. 15° E. N.	65° E. 45° W.	N. 75° W.	90°	....	....	(Bottom joints.)	....	....	....	....
[illegible]	N. 20° E.	(?)	N.	40°-70° E.	N. 15° E. N. 10° E.	62° E. 30° W.	N. 75° E.	90°	....	....	....	....	....	....	....
[illegible]	N.+	E. low.	N.	40° E.	N. 5° E.	65° E.	E.-W.	90°	....	....	....	....	....	....	....
[illegible]	N. 25° E.	25° E.	N. 15° E.	50° E.	N. 7° E. N. 25° E.	50° E. 45° W.	....	....	....	....	....	....	....	....	....
[illegible]	N.+	37° E.	N. 15° E.	55° E.	....	....	....	....	....	....	....	E.-W. NE.	S. high NW.	....	....
[illegible]	N.+	30° E.±	N.+	50° E.±	N.+	E. high.	....	....	....	....	....	NE. or N.	40° NW. or W.	....	....
[illegible]	N.+	20° ± E.	N.+	40° ± E.	N.+ N.+	90° 30° W.	....	....	....	....	....	....	....	....	....
[illegible]	....	50° E.?	N.	37° E.	N. 12° W.	60° E.	E.-W. E.-W.	55° W. 90°	....	....	....	....	....	....	....
[illegible]	....	....	N.	35° E.	N. 10° E. N.	55° E. 40° E.	N. 82° E.	90°	....	....	Feeble.	N.	50° E.	....	....
[illegible]	N.+	30° E.	N. 10° W.	50° E.	N.	60° W.	E.-W.	90°	....	....	N. 45° E.	NE.±	57° NW.	....	....
[illegible]	N.+	17° E.	N. 5° W.	42° E.	....	....	E.-W.	90°	....	....	....	....	....	....	....
[illegible]	(?)	(?)	N. 20° W.	40° E.	N. 5° W.	55° W.	N. 80° E.	90°	....	....	N. 80° W.	N. 45° E.	70° NW.	....	....
[illegible]	N. 25° W.	30° E.	N. 25° W.	32° E.	N. N.+	75° E. 45° ± W.	....	....	....	....	....	....	....	....	....
[illegible]	(?)	(?)	N. 17° W.	40° E.	N. 10° W.	50° E.	N. 65° E.	90°	....	....	....	....	....	....	....
[illegible]	(?)	(?)	N. 25° E.	65° E.	....	....	....	....	....	....	....	....	....	....	....
[illegible]	N.	−45° E.	N. 15° E.	45° E.	N.+	42° W.	....	....	N. 50° W.	70° SE.	....	....	....	....	....
[illegible]	N.+	20° E.	N. 12° E.	40° E.	....	....	N. 70° W.	70° ESE.	....	....	....	....	....	....	....
[illegible]	N.	25° E.	N. 15° E.	37° E.	....	....	....	....	....	....	....	....	....	....	....
[illegible]	N.+	20° E.	N.+	27° E.	....	....	....	....	....	....	....	....	....	....	....
[illegible]	N.+	22° E.	N.+	35° E.	....	....	....	....	....	....	....	....	....	....	....
[illegible]	(?)	(?)	N. 10° W.	45° E.	N.	75° E.	E.-W.	90°	....	....	....	N. 10° W.	45° E.	....	....
[illegible]	N. 10° W.	Fold.	N. 10° E.	20° E.	....	....	....	....	....	....	....	....	....	....	....
[illegible]	N. 7° W.	45° E.	N.	30° E.	N. 18° E.	45°+	E.-W.	90°	....	....	....	....	....	....	....
[illegible]	N.+	35°-65° E.	N. 7° W.	50° to 65° E.	N	90°	E.-W.	90°	....	....	....	....	....	....	....
[illegible]	N. 15° E.	60° E.	N. 15° E.	60° E.	....	....	....	....	....	....	....	....	....	....	....
[illegible]	N. 55° E.	20° E.	N. 30° E.	25° E.	N. 20° E.	60° E.	....	....	....	....	....	....	....	....	....
[illegible]	N. 25° E.	20° E.	N. 7° E.	25° E.	N. 25° E.	45° E.	N. 80° W.	80° N.	N. 30° E. N. 40° E.	45° E 50° SE.	N. 60° W.	N. 55° E. N. 40° E.	87° NW. 80° NW.	N. 80° E.	35° S.

Slate-quarry observations in Vermont—Continued.

Quarry No. on Pl. XX or XXI.	Bedding.		Cleavage.		Strike joints.		Dip joints.		Diagonal joints.		Grain strike.	Shear zones ("hog-backs").		Faults.	
	Strike.	Dip.	Strike.	Dip.	Strike.	Dip.	Strike.	Dip.	Strike.	Dip.		Strike.	Dip.	Strike.	Dip.
49			N. 25° W.	20° E.			E.-W.	90°	N. 35° E.	60° SE.					
50	N.	20° E.	N. 27° E.	30° E.	N. 5° W.	30° E.	N. 65° W.	90°							
51		0°	N.+	17° E.											
52		0°	N. 25° E.	15° E.			N. 70° E.	90°						Along cleavage.	
53	N. 40° W.	Fold.	N. 15° E.	E. low.											
54	N. 17° W.	30° E.	N. 5° E.	20° E.											
56	N. 75° W.	17° S.	N. 42° E.	15° E.	N. 22° E.	60° E.									
57	N.+	7° W.	N.+	17° E.											
58	N.+	15° W.	N. 10° E.	17° E.											
59	N.	35° E.	N.	42° E.											
60	N.	35° E.													
61	N. 5° W.	37° E.	N.	37° E.											

MINOR STRUCTURAL FEATURES.

The purplish slates in many places include greenish ribbons—calcareous, quartzitic, and chloritic—an inch or two in thickness, and such ribbons run into rows or planes of green spots. The cause of these colored beds and spots has been discussed on page 23. The ribboned slates here, as elsewhere, are used for flagging.

In some of the quarries there are pyritiferous quartzite nodules a few inches in diameter, of lenticular form, lying in the bedding foliation and of sedimentary origin. (See p. 49.)

Faults of no great displacement are not uncommon. These may be reversed or normal. (See Pl. IV, *C*, *E*, and p. 43.)

Veins of milky quartz are abundant, and some of them attain large dimensions. (See Pl. V, *A*, and p. 48.) Their course is in places very irregular. They generally contain calcite and chlorite. The west wall of the Briar Hill quarry (No. 62, Pl. XX), in Pawlet, has many parallel curved tapering veins evidently due to shearing motion and tension.

As shown by the maps (Pls. XX, XXI) the region is traversed by dikes. These measure from 12 to 40 feet or more in width and as much as several miles in length. They are probably of Triassic date and are usually made up of camptonite, consisting chiefly of plagioclase feldspar and hornblende, with or without augite.[1] These dikes are locally parallel to the strike or the dip joints, but more commonly to the diagonal joints.

Shear zones ("hogbacks") are numerous, as is shown by the quarry diagrams (Pls. XXIII, XXIV). From their parallelism to the dikes and some of the joints they may all be due to the same earth movement. (See, on shear zones, Pl. VIII and p. 44, and on their relation to dikes, p. 169.)

The quartzite beds, veins, dikes, shear zones, "posts," faults, and diagonal joints add seriously to the difficulties presented by the overturned close folding and the pinching out of folds which characterize this region. False cleavage is, however, exceptional.

The general aspect of good commercial green slate as seen in a large mass broken across the cleavage is well shown in Plate XIX, *A* ("sea-green," quarried for roofing) and *B* ("unfading green," quarried for mill stock).

THE WESTERN VERMONT SLATES.

"Sea-green" slate.—When freshly quarried, the "sea-green" slate varies from a light gray to a slightly greenish gray. In some beds it is crossed by ribbons of a dark gray or, where bedding and cleavage are parallel, it bears traces of organisms in dark gray.

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[1] See Bascom, F., U. S. Geol. Survey Nineteenth Ann. Rept., pt. 3, p. 223-226. 1899.

To the unaided eye the texture is fine and the cleavage surface somewhat so, with a waxy luster. The sawn edges show a little pyrite. It is very slightly magnetitic, effervesces a little under cold dilute hydrochloric acid applied to the edges and much under acid applied to the powdered slate, is sonorous and very fissile. After a few years' exposure it changes its color to a brownish gray, and as the slates from different beds discolor differently a roof covered with "sea-green" slates from different beds acquires a mottled color.

Under the microscope it shows a matrix of muscovite (sericite), with brilliant aggregate polarization and of very fine texture, crossed here and there by obscure traces of bedding or with very minute more quartzose beds parallel to the cleavage. This matrix incloses more or less angular grains of detrital quartz measuring from 0.05 to 0.34 by 0.004 to 0.035 millimeter, but usually 0.035 by 0.013 millimeter, and an occasional grain of plagioclase (lime-soda) feldspar up to 0.04 by 0.05 millimeter. Sections parallel to the cleavage show many plates and rhombs of carbonate, the rhombs measuring from 0.003 to 0.03 or even 0.05 millimeter in diameter. Some of these consist of two crystals, an inner rhomb and an outer one, with different orientation, possibly in twinned position. In some of the double rhombs the inner one has fallen out; in others the rhomb has an opaque mineral nucleus which is not pyrite but may be magnetite or graphite. There are also a few scales of chlorite with interleaved muscovite up to 0.13 millimeter, their laminæ crossing the cleavage and mostly in the grain direction, and some equally large muscovite scales, possibly of sedimentary origin. There are some irregularly distributed pyrite spherules from 0.003 to 0.02 millimeter, also minute lenses of pyrite. Rutile needles, measuring from 0.0017 to 0.009, rarely 0.012, by 0.002 millimeter average about 65,000 to the square millimeter, which is equivalent to about 40,000,000 to the square inch of thin section. Here a and there is a grain of zircon or prism of tourmaline 0.022 by 0.008 millimeter.

The chief constituents of this slate, named in descending order of abundance, appear to be muscovite, quartz, carbonate, chlorite, rutile, pyrite, and magnetite.[1]

In order to ascertain the cause of the discoloration thin sections across the discolored surface of a slate which had been exposed three years were examined and it was found that while the carbonate rhombs within the body of the slate were transparent in ordinary light those at the surface were changed to the color of limonite. These rhombs measured 0.047 millimeter. A cleavage surface of the same slate was also affixed to the glass slide and the other side was ground down. This showed a multitude of rhombs, generally ranging in size from 0.008 to 0.013 millimeter, entirely or partly altered to limonite. In some places there was a yellowish-brown zone of alteration surrounding an unaltered nucleus. These rhombs are regarded by Dr. Hillebrand (see p. 55) as an isomorphous mixture of dolomite and siderite—that is, a carbonate of lime, magnesia, and iron, in which the iron (ferrous carbonate) oxidizes into limonite. The only way to prevent this discoloration would be to coat the slate with some preparation which would protect it from oxidation.

Some of the "sea-green" slates are termed hard, others soft. The difference, judging from microscopic evidence, seems to be due to the greater percentage of carbonate in the soft ones and the larger size of the quartz grains in the hard ones.

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[1] For colored lithographs of magnified thin sections of this slate as seen under both ordinary and polarized light, see U. S. Geol. Survey Nineteenth Ann. Rept., pt. 3, Pl. XXXV, 1899.

The following complete analyses of "sea-green" slate were made by W. F. Hillebrand:

Analyses of Vermont "sea-green" roofing slate.

	A	B	C	D
Silica (SiO_2)	67.76	62.37	59.84	65.29
Rutile, titanium dioxide (TiO_2)	.71	.74	.74	....
Alumina (Al_2O_3)	14.12	15.43	15.02	....
Ferric oxide (Fe_2O_3)	.81	1.34	1.23	....
Ferrous oxide (FeO)	4.71	5.34	4.73	....
Manganese oxide (MnO)	.10	.22	.34	....
Nickelous and cobaltous oxide (NiO, CoO)	Trace?	Trace.	Trace.	....
Lime (CaO)	.63	.77	2.20	....
Baryta (BaO)	.04	.07	.09	....
Magnesia (MgO)	2.38	3.14	3.41	....
Potassa (K_2O)	3.52	4.20	4.48	....
Soda (Na_2O)	1.39	1.14	1.12	....
Lithia (Li_2O)	Strong trace.	Trace.	Strong trace.	....
Water below 110° C. (H_2O)	.23	.34	.41	....
Water above 110° C. (H_2O)	2.98	3.71	3.44	....
Phosphoric oxide (P_2O_5)	.07	.06	.09	....
Carbon dioxide (CO_2)	.40	.87	2.98	....
Pyrite (FeS_2)	.22	.06	.05	....
Sulphuric oxide (SO_3)	Trace.	Trace.	Trace.	....
Carbon (C)	None.	Strong trace.	Trace.	....
Fluorine (Fl)	....	....	.11	....
	100.07	99.80	100.28	....
Total sulphur (S)	.12	.032	.024	....

A (=D. XIV, 1895, 230a). Rising & Nelson's quarry No. 2, West Pawlet, Vt.; 13-foot bed.
B (=D. XIV, 1895, 225f). Griffith & Nathaniel's quarry, 9 miles north of A, South Poultney, Vt.
C (=D. XIV, 1895, 256e). Wm. H. Hughes's quarry No. 10 (Brownell), 2 miles north of A, Pawlet, Vt.
D (=D. XIV, 1895, 35l). Auld & Conger's quarry, 8 miles north of A, in Wells, Vt.; 22-foot bed. Determination of silica only.
These are all from the West Pawlet and South Poultney belt. Specific gravity: C, 2.7910; D, 2.7627.

This slate is used exclusively for roofing. The results of Merriman's tests of it are given on page 183.

"*Unfading green*" *slate.*—The slate called "unfading green" is greenish gray in color.

To the unaided eye it has a somewhat fine texture and a roughish lusterless cleavage surface. The sawn edges show some pyrite. It is magnetitic, does not effervesce with cold dilute hydrochloric acid, even when powdered, and is sonorous. Several years' exposure produces so little change of color that only when a fresh slate is put beside it is any change perceptible, and that is but slight. Its fissility is inferior to that of the "sea-green."

Under the microscope it shows a matrix of muscovite (sericite), with a brilliant aggregate polarization but considerable inequality in texture, coarser quartzose bands, with imperfect cleavage, alternating with finer more sericitic ones. In both there is irregularity in the size of the particles. Angular quartz grains measure from 0.01 by 0.008 to 0.04 by 0.017, rarely 0.07 by 0.017 millimeters. There are a few lenses up to 0.2 by 0.1 millimeter of quartz fragments and muscovite scales, also lenses up to 0.4 by 0.1 millimeters of chalcedonic quartz (?) A few grains of plagioclase feldspar; scales of chlorite up to 0.039 by 0.006 millimeters parallel to the grain, and also scales of muscovite in similar position; not a few specks and lenses of pyrite, some octahedra of pyrite with rim of chlorite; carbonate rhombs—0.026 to 0.065 millimeter—but in very much smaller number than in the "sea-green" slate; abundant rutile needles from 0.003 to 0.008 millimeters long.

The chief constituents of this slate, named in descending order of abundance, appear to be muscovite, quartz, chlorite, carbonate, rutile, pyrite, and magnetite.[1]

These slates are relatively unfading, because they have fewer rhombs and plates of carbonate. (See Dr. Hillebrand's note, p. 55.) The sections also show why they cleave less perfectly than the "seagreen" slates.

The following analyses were made in the laboratory of the United States Geological Survey by W. F. Hillebrand:

Analyses of Vermont "unfading green" roofing slates.

	E	F		E	F
Silica (SiO_2)	59.27	59.48	Lithia (Li_2O)	Trace.	Trace.
Titanium dioxide, rutile (TiO_2)	.99	1.02	Water below 110° C. (H_2O)	0.32	0.17
Zirconia (ZrO_2)	....	Trace?	Water above 110° C. (H_2O)	3.98	4.05
Alumina (Al_2O_3)	18.81	18.22	Phosphoric oxide (P_2O_5)	.11	.10
Ferric oxide (Fe_2O_3)	1.12	1.24	Carbon dioxide (CO_2)	.21	.39
Ferrous oxide (FeO)	6.58	6.81	Pyrite (FeS_2)	.15	.13
Manganous oxide (MnO)	.13	.07	Sulphuric oxide (SO_3)	Trace.	....
Nickelous oxide (NiO)	Trace?	Trace?	Carbon (C)	None.	None.
Cobaltous oxide (CoO)	Trace?	....	Fluorine (Fl)	....	.08
Strontia (SrO)	....	Trace?			
Lime (CaO)	.42	.56	Total	99.98	100.23
Baryta (BaO)	.05	.05			
Magnesia (MgO)	2.21	2.50	Total sulphur included above (S)	.08	.07
Potassa (K_2O)	3.75	3.81			
Soda (Na_2O)	1.88	1.55	Specific gravity	2.795	....

E (=D. XIV, 1895, 314*f*). Eureka quarries, 3½ miles north of Poultney, in Poultney Township, Vt.
F (=D. XV, 1896, 645*a*). Valley Slate Co. quarry, 2½ miles north of Poultney, in Poultney Township, Vt.

The results of Merriman's recent tests of Vermont unfading green slate will be found on page 183.

This slate is largely used for roofing. The mill stock slate is described beyond.

"Purple" and "variegated" slate.—The "purple" slate is dark-purplish brown; the "variegated" is like the "sea-green" and the "unfading green" but is irregularly patched with purplish brown. These purplish slates are interbedded both with the "sea-green" and the "unfading green," as shown in the quarry diagrams (Pls. XXIII, XXIV).

The texture, surface, and luster correspond generally to those of the slates with which they are interbedded. The "purple" slate of the "sea-green" areas discolors less than the "sea-green" but effervesces with cold dilute hydrochloric acid and is very slightly magnetitic. The "variegated" slate of the Eureka quarry does not effervesce with cold dilute hydrochloric acid. All these slates are sonorous.

Under the microscope the purplish slate closely resembles the green, with which it is associated, both in structure and composition, excepting that the purplish contains a large amount of hematite (Fe_2O_3) in irregular bright red dots from 0.001 to 0.003 millimeter in diameter, exceptionally in hexagonal scales. This mineral obscures the aggregate polarization. There are quartz fragments up to 0.047 and even 0.07 millimeter, rare plagioclase grains; lenses of quartz a millimeter long; muscovite and chlorite scales lying at an angle to the cleavage, others without arrangement. Carbonate is less abundant than in the green slates. Spherules of pyrite from 0.007 to 0.027 millimeter, rutile needles in abundance, a few prisms of tourmaline, and rare fragments of zircon.

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[1] For colored lithographs of magnified thin sections of this slate, as seen both under ordinary and polarized light, see U. S. Geol. Survey Nineteenth Ann. Rept., pt. 3, Pl. XXXVI, 1899.

The chief constituents of the "purple" slate, named in descending order of abundance, appear to be muscovite, quartz, chlorite, hematite, carbonate, rutile, pyrite, and magnetite. The purplish color is due to the mixture of the red from the hematite and the bluish green from the chlorite.[1] In the "variegated" slates the mottling is produced by the irregular distribution of the hematite.

The following analyses were made by W. F. Hillebrand in the laboratory of the United States Geological Survey:

Analyses of Vermont "purple" and "variegated" roofing slates.

	G	H	I	H^2
Silica (SiO_2)	61.63	60.96	60.24	....
Titanium dioxide, rutile (TiO_2)	.68	.86	.92	....
Zirconia (ZrO_2)	....	Trace?	Trace?	....
Alumina (Al_2O_3)	16.33	16.15	18.46	....
Ferric oxide (Fe_2O_3)	4.10	5.16	2.56	5.28
Ferrous oxide (FeO)	2.71	2.54	5.18	2.36
Manganous oxide (MnO)	.09	.07	.07	....
Nickelous oxide (NiO)	Trace?	Trace.	Trace.	....
Cobaltous oxide (CoO)	Trace?	Trace.	Trace.	....
Lime (CaO)	.50	.71	.33	....
Baryta (BaO)	.06	.04	.03	....
Magnesia (MgO)	2.92	3.06	2.33	....
Potassa (K_2O)	5.54	5.01	4.09	....
Soda (Na_2O)	1.26	1.50	1.57	....
Lithia (Li_2O)	Str. tr.	Trace.	Str. tr.	....
Water below 110° C. (H_2O)	.31	.17	.18	....
Water above 110° C. (H_2O)	3.24	3.08	3.81	....
Phosphoric oxide (P_2O_5)	.16	.23	.11	....
Carbon dioxide (CO_2)	.41	.68	.08	....
Pyrite (FeS_2)	.04	None.	.16	....
Sulphuric oxide (SO_3)	Trace.	....	....	....
Carbon (C)	None.	None.	None.	....
	99.98	100.22	100.12	....
Total sulphur (S)	.02	.07	.087	....
Specific gravity	2.8064	....	2.8053	....

G (=D. XIV, 1895, 260*a*), purple roofing slate, McCarty quarry, east of center of Lake St. Catherine, South Poultney, Vt.

H (=D. XV, 1895, 760*a*), purple roofing slate, Francis & Sons' quarry, nearly a mile south of Hydeville, in Castleton, Vt.

I (=D. XV, 1895, 314), variegated roofing slate, from Eureka quarry 3½ miles north of Poultney, in Poultney Township, Vt., "unfading green" area.

H^2 (=D. XIV, 1895, 614*a*), dark-reddish bed a few inches thick in purple of "sea-green" area, west of Lake St. Catherine; determination of iron oxides only.

The results of certain tests of the strength of Fair Haven "purple" slate are given on page 183. The "purple" and "variegated" slates are used mainly for roofing.

Mill-stock slate.—In the northern and western parts of the green-slate belt those beds which have a less perfect cleavage are used as mill stock and find a market as blackboards, billiard-table tops, electric switchboards, tiles, vats, mantels, etc., and for some purposes are subjected to the process known as "marbleizing." They are purple or green. Much of the purple is paler than the "purple" roofing slate and also spotted with green, and some of the green is brighter than the "unfading green" roofing slate.

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[1] For colored lithographs of magnified thin sections of the "purple" slate, as seen under both ordinary and polarized light, see U. S. Geol. Survey Nineteenth Ann. Rept., pt. 3, Pl. XXXVII, 1899.

Specimens from the Scotch Hill quarries, 2 miles north-northeast of Fair Haven; from the Meadow quarry, one-fourth mile east of Fair Haven; from the Lake Bomoseen Slate Co.'s quarry at Cedar Point, on Lake Bomoseen;[1] and from the J. Jones quarry, 2½ miles north of Castleton, were examined miscroscopically, with these results:

The matrix is muscovite (sericite), with aggregate polarization, but shows a cleavage much inferior to that of the "sea-green" slate and somewhat inferior to that of the Eureka of the "unfading green." There are about six chlorite plates, interleaved with muscovite, to each square millimeter, measuring up to 0.087 by 0.043 millimeter, and lying at right angles to the cleavage. Quartz fragments are very abundant, measuring up to 0.06 by 0.03 millimeter, with a few of plagioclase feldspar; muscovite scales in various orientations; a few carbonate rhombs, the usual abundance of rutile needles, and, finally, pyrite, which seems to be more abundant in the purple than in the green. The purple differs from the green by the addition of hematite.

The chief constituents, named in descending order of abundance, appear to be muscovite, quartz, chlorite (hematite in the purple), carbonate, rutile (kaolin in the purple, at least), pyrite, and, as shown by a magnet test, magnetite.

The specific gravity of the purple from Cedar Point was found to be 2.83 and of the green from the J. Jones quarry 2.84, both being a little higher than the figures for any of the other slates of western Vermont.

Slate-pencil slate.—In the portion of the belt containing the "unfading green" slate, about 1¼ miles north of Bomoseen and a little east of the lake, is an abandoned quarry where certain greenish slates were obtained and made into slate pencils. In Europe slate pencils have long been made by utilizing a secondary cleavage, which breaks the rock up into squarish sticks that are easily rounded. In the Vermont quarry the method used was to take tile-shaped blocks of slate and carve out first on one side, then on the other, by means of set gages, a whole series of hemicylindrical pencils which readily broke apart into roundish pencils.

A microscopic section of this rock shows essentially the same composition as that of the "unfading green" slates, except that sections parallel to the cleavage show no carbonate whatever, but a greater abundance and larger scales of muscovite (probably sedimentary), some limonite(?) specks, and a cleavage perhaps not quite so good as that of the Eureka quarries. The usual quartz, sericite, chlorite, rutile needles, and lenses are present.

The general substitution of paper tablets for school slates in this country has almost stopped the manufacture of slate pencils.

Minerals associated with the green and purple slates.—As the minerals of visible size associated with the slates throw light on the nature and origin of the microscopic constituents of the slate itself, they are here noted.

Quartz is the most common accessory mineral. It is usually segregated in the veins already described but occurs also as an infiltrated cement between the quartz grains in the beds of quartzite or in veins traversing the quartzite. In both of these modes it is crystallized wherever cavities admit of crystallization.

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[1] See Pls. XIX, *A*, and XXIV, *N*, for the structure at this quarry.

Next in abundance is calcite, occurring also in veins with or without quartz, or as delicate films on joint planes, or as a sediment in the beds of quartzite. Some of the quartzite beds contain minute rhombs which effervesce readily with hydrochloric acid and weather a limonite-brown and are therefore probably a double carbonate of iron and lime.

Squarish or oval concretions an inch by three-fourths of an inch and one-half inch thick, consisting of radiating crystalline lamellæ of barite, with the intervening spaces filled with slate and calcite and with many minute cubes of pyrite round about, occur in the Cambrian green slates of Middle Granville. Barite also occurs with calcite in crystalline films on joint planes.

Chlorite is common in quartz veins or almost alone makes up small veins or coats slickensided joint or bedding planes.

Pyrite occurs in cubes up to one-fourth inch across or in botryoidal concretions, coated with fibrous quartz (chalcedony) or with calcite or, more rarely, chlorite. This coating of chalcedony is in places confined to some of the sides, filling a space produced by motion or compression, as described by Renard. Pyrite may collect in the vicinity of calcareous and quartzose veins or beds, or form dendritic crystallizations on cleavage planes, or minute cubes on joint faces. That this mineral is pyrite and not marcasite is shown by its not decomposing readily after long exposure on the slate dumps.[1]

Rarely a little galenite occurs in the quartz veins.

It will be observed that nearly all the above-named minerals have already been mentioned as occurring in the slates, as shown either by the microscopic or the chemical analyses.

Black slate near Benson.—Half a mile east of Benson village and 7½ miles north-northwest of Fair Haven, in Rutland County, black roofing slate was quarried in 1895, but the quarry was abandoned not long afterward. The slate is probably of Ordovician age and belongs in a shale, slate, and schist belt which extends nearly 4 miles west to a point within a mile of Lake Champlain, and 4½ miles south-southwest to the village of West Haven, and also, with bends and ramifications, 20 miles north-northeast to Weybridge Center, in Addison County. The slate-bearing area, however, probably does not exceed 3 square miles.

At the quarry the beds dip about east at angles ranging from 15° to 20°; cleavage strikes about N. 7° E., dipping 35° E., and vertical joints strike N. 75° W.

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[1] See footnote on pyrite and marcasite, p. 174.

The slate is bluish black. To the unaided eye it has a somewhat fine texture and a rather smooth, slightly lustrous cleavage surface. It is carbonaceous or graphitic, contains a little magnetite, effervesces with cold dilute hydrochloric acid, is sonorous, and has a fair degree of fissility.

Under the microscope it shows a matrix of muscovite (sericite), with a brilliant aggregate polarization, somewhat obscured by much carbonate and carbonaceous matter in fine and coarse particles. The quartz fragments measure from 0.013 to 0.03 millimeter; carbonate rhombs from 0.004 to 0.035 millimeter. Pyrite spherules from 0.0017 to 0.007 millimeter number about 17,000 to the square millimeter, many of them occurring in rows along the cleavage. Rutile needles from 0.0017 to 0.0952 millimeter long are abundant; chlorite scales are very few and small, zircon fragments rare.

The constituents of this slate, named in descending order of abundance, appear to be muscovite, quartz, carbonate, pyrite, rutile, carbonaceous or graphitic matter, and magnetite.

This slate is thus closely related, both in composition and quality, to the "soft vein" slates of Lehigh and Northampton counties, Pa. Its large amount of carbonate indicates its probable discoloration on continued exposure. Its appearance in magnified thin sections under both ordinary and polarized light is very well shown in Plate XXXIX, Nineteenth Annual Report United States Geological Survey, part 3, a view which would answer almost equally well for many of the "soft vein" slates of Pennsylvania.

The following analysis (specimen P=D, XIV, 1895, 305*d*) of black slate from the abandoned quarry, one-fourth mile east of Benson Village, Rutland County, Vt., was also made by W. F. Hillebrand:

Analysis of black roofing slate from quarry near Benson, Vt.

Silica (SiO_2)	59.70	Lithia (Li_2O)	Strong trace.
Titanium dioxide, rutile (TiO_2)	.79	Water below 110° C. (H_2O)	.30
Alumina (Al_2O_3)	16.98	Water above 110° C. (H_2O)	3.82
Ferric oxide (Fe_2O_3)	.52	Phosphoric oxide (P_2O_5)	.16
Ferrous oxide (FeO)	4.88	Carbon dioxide (CO_2)	1.40
Manganous oxide (MnO)	.16	Pyrite (FeS_2)	1.18
Nickelous oxide (NiO)	Trace?	Sulphuric oxide (SO_3)	Trace.
Cobaltous oxide (CoO)	Trace?	Carbon (C)	.46
Lime (CaO)	1.27		
Baryta (BaO)	.08		100.05
Magnesia (MgO)	3.23	Total sulphur (S)	.63
Potassa (K_2O)	3.77	Specific gravity	2.7748
Soda (Na_2O)	1.35		

The more important features of all these Vermont slates, as brought out in the above descriptions, will be found in tabular form opposite page 188.

VIRGINIA.

W. B. Rogers,[1] in his reports to the legislature of Virginia during the years 1835 to 1841, called attention to the slate deposits east of the Blue Ridge in Buckingham, Fluvanna, and Fauquier counties.

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[1] A reprint of annual reports and other papers on the geology of the Virginias [posthumous]; on the roofing slate of Buckingham County, pp. 78, 79; on that of Fauquier County, pp. 460, 461, New York, 1884.

Slate also occurs in the Blue Ridge in Amherst County and Albemarle County.

Recent field studies of these slate areas by T. L. Watson and S. L. Powell, of the Virginia Geological Survey,[1] have thrown more light on their geographic and geologic relations and their geologic age; and N. H. Darton's discoveries of fossils in the slate of the Arvonia district, announced in 1892,[2] determined the general geologic age of that belt. According to the studies of Watson and Powell and their map, reproduced in figure 12, there are three slate belts, of which the Amherst-Bedford County belt is the most westerly, the Buckingham-Fluvanna County and Quantico belt the most easterly, and the Albemarle-Fauquier County belt the central. Economically considered the slates in both the central and eastern belt vary considerably. The slate of the eastern belt is of Ordovician age; that of the central and western belts belongs to the Cambrian.

Geologic relations in Buckingham and Fluvanna counties.—Rogers's reference[3] to the slate of Buckingham and Fluvanna counties may well be repeated here:

> This [roofing slate] makes its appearance on both sides of the James River. * * * In Buckingham the bed is largely exposed in the neighborhood of New Canton, on Slate River. * * * In texture, density, and capacity of resisting atmospheric agents it can scarcely be excelled by a similar material in any part of the world. This quarry was first opened to procure slate for roofing the capitol, and notwithstanding it has been thus long known and its value established, but little further use has been made of it until the activity of the present owner has again brought it into notice. The building of the university will soon be furnished with a complete covering of slate from this quarry.

Slate River empties into the James about 40 miles west-northwest of Richmond and 52 miles northeast of Lynchburg. The extent and structure of the formation which includes these slate beds require further study, but figure 13 will serve to show some of its important features. The width of the formation north of the James, as far as explored by the writer during a very brief visit, extends from a point half a mile west of Bremo Bluff to a small creek entering the James 1⅖ miles east-southeast of Shores, a distance of 1⅗ miles. It strikes about south-southwest across the James and extends at least a mile south of Penlan, or 5¼ miles from the south bank of the James. This, on the scale of the map, would be three-fourths of an inch beyond its lower margin. South of the James its eastern boundary lies about 3,000 feet west of the toll bridge opposite Bremo Bluff, and its western boundary is roughly one-fourth mile east of the Virginia Mills, on Slate River. The bluffs on the north and south

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[1] Watson, T. L., and Powell, S. L., Fossil evidence of the age of the Virginia Piedmont slates: Am. Jour. Sci., 4th ser., vol. 31, pp. 33-44, and map, fig. 1, 1911.

[2] Darton, N. H., Fossils in the "Archean" rocks of central Piedmont, Virginia: Am. Jour. Sci., 3d ser., vol. 44, pp. 50-52, 1892.

[3] Op. cit., p. 79.

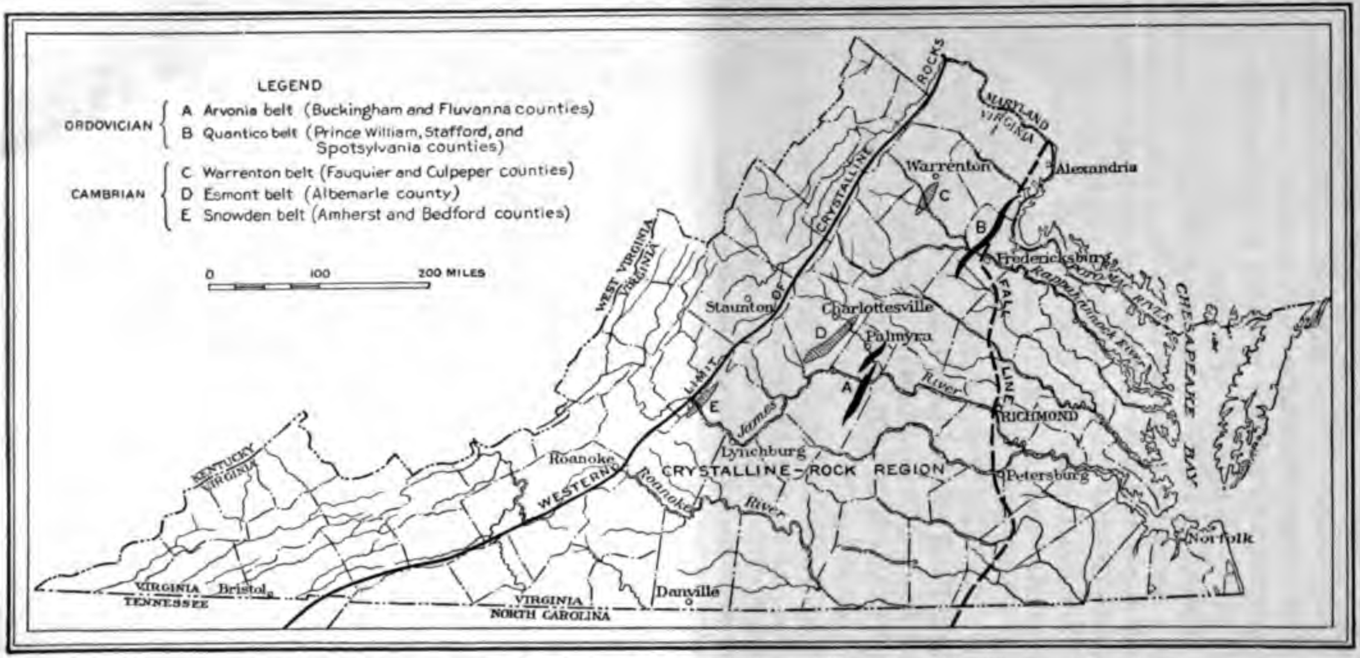

FIGURE 12.—Map of Virginia, showing distribution of slate areas in the crystalline region. After Watson and Powell.

sides of the James at Bremo Bluff, New Canton, consist of quartzite with like strike and dip—on the north, strike N. 17°–23° E., dip 65° E. and 90°; on the south, strike N. 13°–18° E., dip 90°. The exposure of quartzite on the north is about 950 feet across the strike

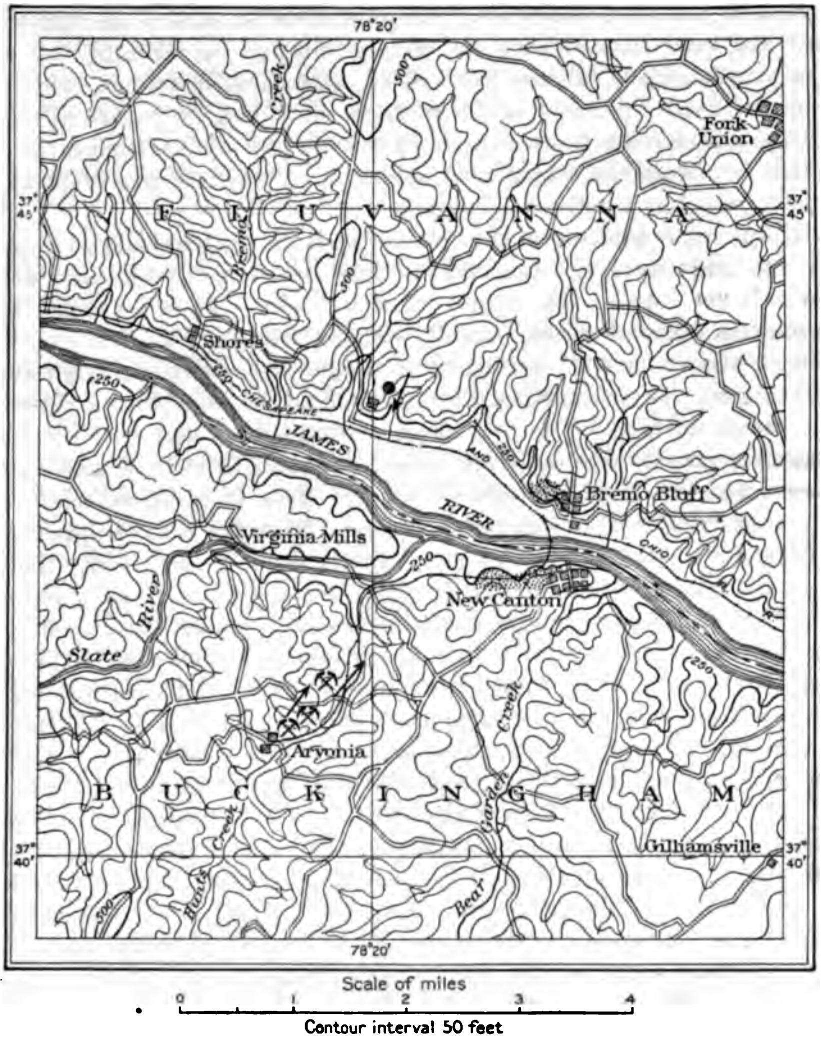

FIGURE 13.—Map of slate region in Buckingham and Fluvanna counties, Va. Quarries shown by crossed hammers; slate prospect by round dot; strike of commercial slate by arrows; quartzite areas by fine dots.

and on the south about 3,000 feet. These facts and the jagged structure of the Bremo Bluff, which is 75 feet high, [illegible] the James here flows through a broad transverse cut [illegible] and the slate formation west of it. This quart [illegible] muscovitic, and biotitic, with scattered plates of calcite and a few fragments of plagioclase. It is interbedded here and there with a few inches of slate, consisting of muscovite (sericite), quartz, chlorite, and biotite and containing garnets and lenses of quartz, muscovite, and chlorite, some of which are probably altered garnets. The quartzite also has slate of this character on both sides of it. On the east the quartzite, dipping 80° E., is followed conformably by 40 feet of such slate, about 300 feet of micaceous quartzite, and an undetermined thickness of ferruginous slate full of pseudomorphs or crystals of mica (muscovite?) 1½ millimeters across, the plates of which lie across the foliation of the rock. This slate was originally bluish gray but weathers a hematite-red.

The general structure of the belt in which the commercial slate beds lie, to judge from the railroad cuttings between New Canton and Slate River, appears to consist of minor folds. It is traversed by numerous dikes of olivine basalt, ranging from a few inches to 12 feet in thickness and consisting of plagioclase, olivine, magnetite, and augite. These dikes weather in conchoidal masses with a yellowish brown surface. The formation is bounded on the east by the quartzite cut by James River. If this quartzite is in a westward overturned syncline, it would overlie the slate; if in an anticline of like character, it would underlie the slate, in either case in apparent conformity. On the west of the formation at Virginia Mills there are chloritic, sericitic, quartzose, and feldspathic schists striking N. 25° E. and dipping 90°, crossed diagonally by a small basaltic dike, also certain chloritic, quartzose, and feldspathic schists that weather bright red, possibly the same as the above, but both of uncertain age.

The commercial slate itself appears to occupy a belt two-fifths of a mile wide along Hunts Creek, which is a southern tributary of Slate River. At Penlan its strike is N. 30° E. At Arvonia its course is N. 35° E., roughly like that of Hunts Creek, which meanders through it; but on the north side of the James, 3½ miles north-northeast of Arvonia, the strike of the slate is N. 20° E., like that of the quartzite at Bremo Bluff. There appears thus to be a bend in the slate beds between Arvonia and the north side of the James. The discovery of certain crinoids and later of brachiopods, trilobites, etc., in the quarried slate at Arvonia shows it to be of Ordovician age. E. O. Ulrich, to whom collections of these fossils were referred, determines them as unquestionably of Ordovician age, but he finds that the fossils are of such strange types that it will require a very critical study to determine whether the beds are Mohawkian or Cincinnatian. The dikes are probably of Mesozoic age.[1] C. D. Walcott, as cited by Darton,[1] regards the crinoids from the slates at Arvonia as allied to the genera Schizocrinus, Heterocrinus, and Poteriocrinus. Mr. T. E.

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[1] Darton, N. H., loc. cit.

Williams, of Arvonia, recently found in the Middle quarry an unusually well-preserved crinoid. The cup, as compressed, is 3 inches high and 2¼ inches wide at the top. Seventeen tentacles, thickly fringed with pinnulæ up to an inch in length, cover an area of the slab 14 by 8 inches. The specimen is at the National Museum.

Arvonia.—The quarries near Arvonia are scattered along the sides of Hunts Creek for a mile northeast of that place. The principal quarries in operation in May, 1904, were the Old or Big quarry and the Middle quarry of the Williams Slate Co., and the Fontaine quarry of A. L. Pitts. Several others were being opened or were temporarily abandoned. One opened later near the mouth of Hunts Creek had been abandoned in 1912.

The Big quarry in 1904 measured 300 feet along the cleavage, 200 feet across it, and 125 feet in depth. Bedding and cleavage are identical, striking N. 37° E., and dipping 86° SE. There are vertical dip joints striking about northwest; strike joints trending northeast, dipping 75°-80° SE.; also two sets of diagonal joints, one dipping 30° E. and the other 55° W. The latter system had a "post" 5 feet thick full of shear zones. There are also gently undulating "flat joints," to which the grain is parallel. Quartz veins in this quarry contain calcite, chlorite, and biotite. The Middle quarry is 400 feet along the cleavage, 400 feet across, and in places 350 feet deep, with a wing 150 by 50 feet and 100 feet deep. Bedding and cleavage strike N. 33° E., dip 75° S. 57° E., and are crossed by northwesterly vertical joints. There are also horizontal joints spaced 1 to 25 feet. One of these meanders 10° from the horizontal in a distance of 50 feet. At the south end is a vertical dike of olivine basalt, 10 to 12 feet thick, trending N. 25° W., with horizontal joints, 4 to 6 inches apart, for a few feet on its north side and joints parallel to it on both sides. The slate is said to be of better quality a little beyond the zone of these joints than it is at a greater distance from the dike.

The slate from the Williams quarries is very dark gray, with a slightly greenish hue. To the unaided eye it has a minutely granular but very lustrous surface. It is slightly graphitic and magnetitic, shows pyrite on the sawn edge, does not effervesce in cold dilute hydrochloric acid, and is very sonorous and fairly fissile.

Under the microscope it shows a matrix of minute alternating beds, chiefly of fine muscovite, with coarser ones, chiefly of quartz, the former with a brilliant aggregate polarization, the latter with a faint one. These beds are parallel to the cleavage. The quartz fragments measure up to 0.085 millimeter. Scattered throughout both the more micaceous and the more quartzose beds are crystals, lenses, and particles of pyrite, numbering about 25 to each square millimeter and measuring up to 0.09 millimeter, rarely 0.15 and 0.42 millimeter, with their longer axes parallel to the cleavage. These probably include a little magnetite. There are also biotite scales transverse to the cleavage, about 39 to the square millimeter, and measuring up to 0.12, rarely 0.2 millimeter. Almost if not quite as abundant are plates and rhombs of carbonate. There are scattered scales of chlorite interleaved with muscovite, a few grains of plagioclase feldspar 0.047 millimeter, rarely one of zircon, some tourmaline prisms 0.014

millimeter long, much extremely fine graphitic (or carbonaceous?) material, a few particles of hematite, and some rutile needles. Sections parallel to the cleavage are unusually brilliant in polarized light, owing to the abundance of quartz, biotite, and carbonate.

The chief constituents of this slate, named in descending order of abundance, appear to be muscovite and sericite, quartz, biotite, carbonate, graphite, pyrite, chlorite, and magnetite, with accessory plagioclase, zircon, hematite, tourmaline, and rutile.

The Fontaine quarry of A. L. Pitts in 1904 had a length of 300 feet along the cleavage, a width of 200 feet, and a depth of about 100 feet. Bedding and cleavage strike N. 34° E., and dip 80° SE. The quartz veins also contain calcite.

The slate from this quarry is very dark gray with a greenish hue and to the unaided eye has a granular sparkling crystalline texture and a roughish but very lustrous cleavage surface. It is slightly graphitic (or carbonaceous). The sawn edge shows pyrite. It contains rare particles of magnetite, does not effervesce in cold dilute hydrochloric acid, and is very sonorous.

Under the microscope the slate of the Fontaine quarry shows alternating little beds of fine, more muscovitic, and coarser, more quartzose material, the former having a brilliant aggregate polarization. Much of the mica is in the form of muscovite rather than sericite, particularly in the quartzose beds. These beds are parallel to the cleavage. Quartz fragments are abundant, measuring up to 0.12 millimeter. Conspicuous scales of biotite lie across the cleavage, usually up to 0.2 by 0.09 millimeter and averaging about 12 to the square millimeter. Lenses and crystals of pyrite, many of them surrounded by secondary quartz, about 27 to the square millimeter and measuring up to 0.076 by 0.03, rarely 0.34 by 0.03 millimeter, with their longer axes in the cleavage. A few scales of chlorite, interleaved with muscovite, lying across the cleavage and up to 0.3 millimeter. Some carbonate in the coarser beds, here and there with inclusions of an opaque mineral (graphite, pyrite, or magnetite). Much graphitic matter in very minute particles. Some hematite and a few crystals of tourmaline, 0.02 by 0.006 millimeter.

The chief constituents of this slate, named in descending order of abundance, appear to be muscovite and sericite, quartz, biotite, carbonate, pyrite, graphite, chlorite, magnetite, and hematite, with accessory tourmaline.

A specimen from an exceptional bed in the same quarry shows a wrinkled surface from the abundance of biotite lenses measuring half an inch in length by a twentieth of an inch in width at the center. George H. Williams [1] found the joint faces at the old Roberts quarry covered with pyrite and crystals 1 millimeter long, which when analyzed proved to be TiO_2 and which he determined optically as anatase.

Although the slates of Arvonia, as shown by the above determinations, contain some carbonate, they do not include any appreciable amount of ferrous carbonate, for some of these slates put on the old Richmond Theater over 70 years ago did not show any discoloration whatever when removed, about 1902, and some have been on buildings near the quarries over a century without losing any of their blackness. Their highly crystalline character also implies strength and durability.

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[1] Anatase from the Arvon slate quarries, Buckingham County, Va.: Am. Jour. Sci., 3d ser., vol. 42, p. 431, 1891.

The results of Merriman's tests of slate from the Williams and Pitt quarries are given on pages 182–183.

Penlan.—Penlan station is 2 miles about south-southwest of Arvonia. The quarry of the Penlan Slate Co., of Penlan, is a mile farther south. It measures about 100 feet along the cleavage, 150 feet across it, and 100 feet in depth. At 50 feet from the west edge, on the south side, there is a tunnel, 30 feet wide and 50 feet high measured from the quarry bottom, and extending 40 feet along the cleavage. In its upper 10 feet the tunnel has been extended 40 feet still farther. Another tunnel has been made on the north side nearly in line with the west wall. This is 40 feet wide and 50 feet high and extends 40 feet northward along the cleavage. The company expects to extend the first tunnel 500 feet, to sink a shaft to meet its north end, and to work from both ends.

Both cleavage and bedding strike N. 30° E. and dip 80°–85° S. 60° E. There are three sets of joints—(*a*) horizontal, spaced 2 to 10 feet; (*b*) transverse, discontinuous, spaced 2 to 10 feet; (*c*) diagonal, open 3 inches and filled with quartz, graphite, or slate fragments (?). The weathered "top" is 50 feet thick. Whitish disks of calcite of extreme tenuity occur here and there on cleavage faces and have a diameter of 1 or 2 inches. They were evidently deposited by percolating water deriving the lime from the slate itself. These disks are easily removed with dilute muriatic acid and have no economic importance.

The slate has a very dark gray color with a faintly brownish, not bluish, hue. A specimen (D. XXXIV, 16, a), obtained from the company in 1912, and probably finer than the average, has a lustrous, very smooth cleavage surface, which only with a magnifier is seen to be very sparsely and minutely granular. It is very sonorous and very fissile, shows pyrite on the sawn edge, does not effervesce with acid test except when powdered, and contains graphite and some magnetite.

Under the microscope it shows a matrix of muscovite (sericite) with fine texture and brilliant aggregate polarization. Passages and little beds with more and coarser detrital quartz grains, parallel to the cleavage, make the texture somewhat uneven and show that bedding and cleavage are parallel. Particles and crystals of magnetite and of pyrite, 0.02–0.3 millimeter long, average about 5 to the square millimeter. Some of the pyrite is inclosed in secondary quartz. Neither biotite nor chlorite was detected. Fine graphite occurs throughout; considerable carbonate in minute rhombs and plates; tourmaline and rare detrital zircon and plagioclase. Rutile was not detected.

The constituents, named in descending order of abundance, appear to be muscovite, quartz, graphite, carbonate, magnetite, pyrite, tourmaline, plagioclase, and zircon.

This is a highly crystalline mica slate generally identical with that of Arvonia.

The following is a résumé of the results of physical and magnetitic ests of four specimens of this slate made for the company by C. W. Hudson at the Cooper Union Laboratory in New York in 1908:

Tests of slate from Penlan, Va.

Strength, modulus of rupture...pounds to the square inch..	8,000–11,720
Toughness, ultimate deflection, supports 18 to 22 inches apart....inch..	0.266–0.366
Porosity, water absorbed in 24 hours....per cent..	0.152–0.235
Specific gravity....	2.763–2.777
Content of magnetite....per cent..	0.05

The recently opened quarry of the Arvon Slate Manufacturing Co., of Penlan, is about a quarter of a mile southeast of Penlan station nd 1,000 feet east of the railroad. It measures about 130 feet long the cleavage, 50 feet across it, and 50 feet in depth. The veathered "top" is in places 10 feet thick.

The cleavage strikes N. 25° E. and dips 75° S. 65° E. and the attitude f the bedding is probably identical. The foliation has some slight lications, 6 to 12 inches wide, crossed by slip cleavage. There are ransverse vertical joints spaced 1 to 10 feet with a heading 5 feet vide at the south end of the quarry. Irregular horizontal joints are spaced 10 to 20 feet and a diagonal joint strikes N. 20° W.

The slate is of very dark gray shade, like that of the Arvonia quarries, with a faintly brownish, not bluish, tinge, and a lustrous, very granular surface with marked minute plications. The slate is very fissile and sonorous, does not effervesce with acid test unless powdered, shows minute spangles on a rough edge and a little pyrite when sawn, and is graphitic and magnetitic.

Under the microscope this slate has a brilliant aggregate polarization. The cleavage is intersected at 36° by minute plications. Particles of magnetite and pyrite, the former far more abundant, 0.05–0.25 millimeter long, average about 5 to the square millimeter. Crystals and irregular scales of biotite, 0.05–0.3 millimeter long, average 5 or 6 to the square millimeter. The magnetite crystals lie mostly between plates of biotite, and these have secondary quartz on the outer side. Graphite in fine particles throughout; very little carbonate, 3 to 7 small plates to the square millimeter. Very little chlorite; tourmaline; rutile not detected.

The constituents, named in descending order of abundance, appear to be muscovite, quartz, graphite, biotite, magnetite, carbonate, pyrite, chlorite, and tourmaline.

This highly crystalline mica slate, although microscopically slightly different from that of the other Penlan quarry, is generally identical with that of Arvonia.

Bremo Bluff.—Slate has been prospected on the estate of the late Dr. Casey C. Cocke, 2 miles west-northwest of Bremo Bluff, in Fluvanna County. It occurs in the ravine east of the house and also on the hill northeast of it. The strike is N. 18°–23° E., and the dip nearly 90°. A little northwest of the house is a dike of olivine basalt 5 to 10 feet wide. The results of an examination of specimens obtained within a few feet of the surface and therefore belonging to the "top" are given on page 155.

This slate is dark gray, but its lightness of shade is in part the result of weathering. It will prove to be darker below the zone of weathering. To the unaided eye it has a fine texture, with a somewhat fine and very lustrous cleavage surface, more or less dotted with minute lenses or crystals. It is slightly graphitic but not magnetitic, shows pyrite on sawn edges, does not effervesce in cold dilute hydrochloric acid, has an argillaceous odor, and is sonorous and very fissile. The slate from one of the openings has exceedingly minute veins of muscovite.

Under the microscope the slate from the C. C. Cocke estate shows a matrix of muscovite (sericite), with a brilliant aggregate polarization. There are abundant quartz grains up to 0.09 by 0.03 millimeter and 0.13 millimeter long, the larger ones surrounded by secondary quartz radiating along the cleavage; about 35 lenses and crystals of pyrite to the square millimeter, measuring up to 0.09 by 0.02 millimeter (exceptionally the lenses are 1.5 millimeters long), with their longer axes in the cleavage. There are also square and rhombic spaces lined with secondary quartz, measuring up to 0.6 millimeter, left by the dissolution of cubes or distorted cubes of pyrite. In some specimens there are 65 such cavities to the square inch, in others none. There are lenses up to 0.56 by 0.11 millimeter, consisting of quartz and muscovite or of these and chlorite and pyrite, or of chlorite and muscovite, the folia of muscovite and chlorite lying across the cleavage; also muscovite scales up to 0.09 by 0.02 millimeter. Throughout the matrix much dark-gray material occurs in exceedingly fine dots (graphite?). There are also some dots of hematite. Rutile needles are not very plentiful up to 0.01 millimeter long; also a number of very irregular particles of rutile up to 0.05 millimeter, consisting of a network of crystals ("sagenite twinning") forming angles of 120° and 60°. A few fragments of zircon, an occasional crystal of dark tourmaline up to 0.05 by 0.02 millimeter; rare flakes of biotite; no carbonate.

The chief constitutents of the slate, named in descending order of abundance, appear to be muscovite, quartz, pyrite, kaolin, chlorite, graphite, rutile, with accessory tourmaline, zircon, biotite, and hematite.

This slate differs from the slate of the Arvonia area in its finer texture, probable slightly lighter shade, and slightly higher percentage of pyrite. It has less biotite and, at least in the "top," no carbonate. Core drilling or excavation deep enough to penetrate the "top" is amply warranted by the above determinations.[1]

Slate has also been prospected at several other points in Fluvanna County between James River and Palmyra, but no quarry was yet in operation in 1912. A company has been organized and a quarry opened at a point 2 miles northeast of the Bremo mansion and 7 miles south-southwest of Palmyra, a little south of the road, with a course generally parallel to that of the James. (See fig. 13.)

A specimen (D XXXIV, 92, *a*) from this locality, obtained in June, 1913, from J. O. Shepherd, of Palmyra, and reported as having been taken about 7 feet below the surface, is of medium bluish-gray color with a very slight purplish tinge. It has a lustrous roughish cleavage surface dotted with minute blackish lenses, is very fissile and sonorous, very graphitic and magnetitic, and with acid test effervesces very slightly in the powder, but not at all in the rock.

Under the microscope it shows a matrix of sericite with brilliant aggregate polarization. It contains lenses of carbonate up to 0.6 by 0.25 millimeter, numbering about

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[1] Slate outcrops on this property were referred to by J. L. Campbell, Tenth Census, vol. 10, Special report on building stones, p. 181, 1884.

23 to the square inch of transverse section, also crystals and lenses, mostly of magnetite with some of pyrite, up to 0.5 millimeter long by 0.07 millimeter thick and numbering about five to the square millimeter of section with the cleavage but seven to the square millimeter of transverse section. The lenses have radiating secondary quartz and muscovite about them, also chlorite. The pyrite shows limonite stain. The slate also contains prisms of tourmaline and of rutile but no slate needles, also a few grains of zircon. There is much fine graphite but no carbonate besides that in lenses.

The constituents of this slate, named in descending order of abundance, appear to be muscovite, quartz, graphite, chlorite, magnetite, carbonate, pyrite, tourmaline, rutile, zircon, and limonite.

This is a highly crystalline graphitic mica slate of the unfading series, resembling that of Arvonia but of a little lighter shade. It may be found darker as quarrying deepens.

Esmont, Albemarle County.—The slate outcrops of the Esmont district lie east of the Blue Ridge and 10 to 12 miles west of the slate of Buckingham and Fluvanna counties. The quarries are on Ballinger Creek, a small tributary of James River, 5 miles northwest of Warren, on the James, and a mile west of Porter Precinct, as shown on figure 14. A north-northeastward-trending ridge, Green Mountain, attaining an elevation of 800 feet, or 400 feet above the James, lies west of the slate. A diabase dike 50 feet thick, with a northerly course, cuts the slate east of the village and creek.

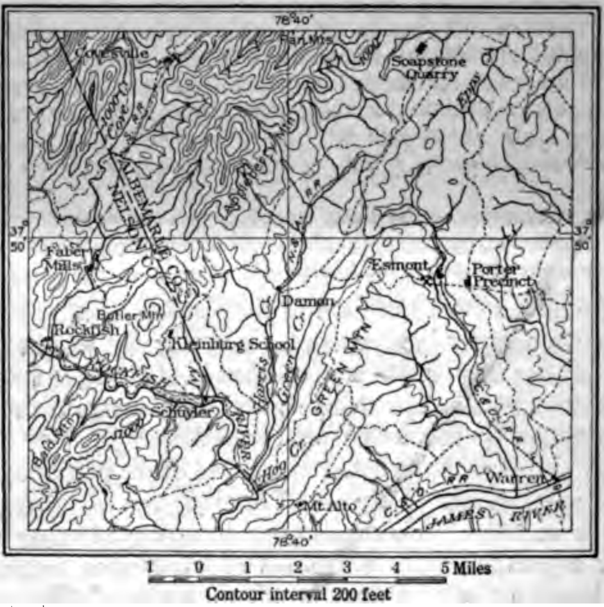
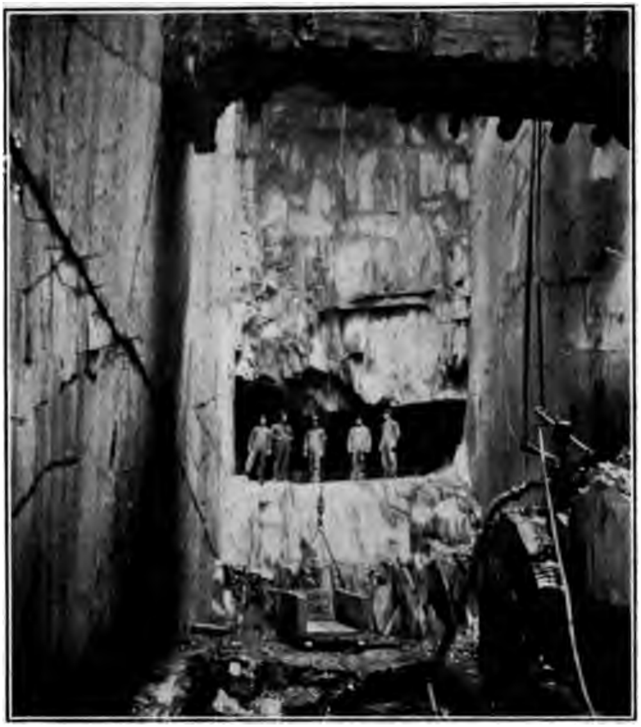


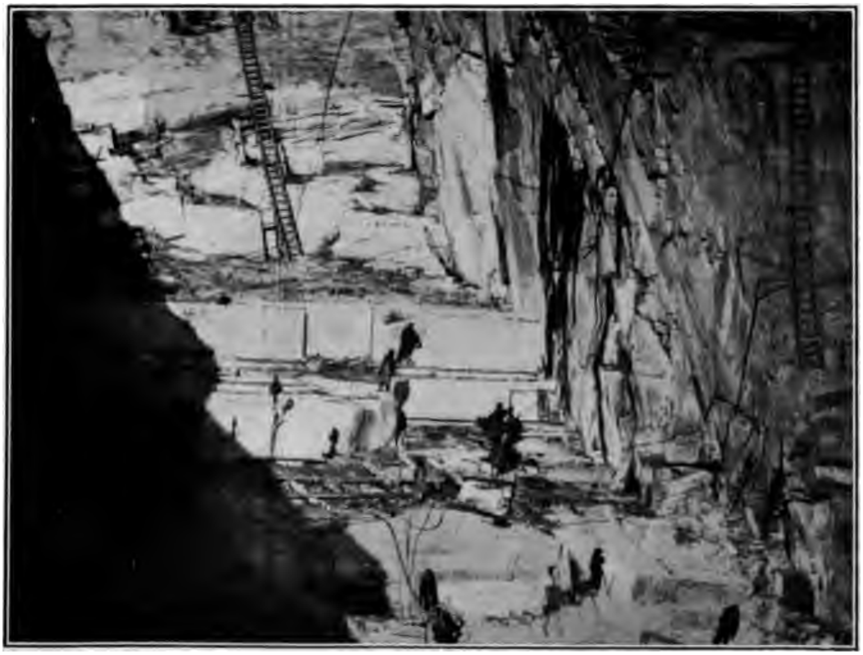
FIGURE 14.—Map of slate region in Albemarle County, Va. Quarry shown by crossed hammers. Course of railroad approximate.

The quarry of the Standard Slate Corporation, of Esmont, lies west of Ballinger Creek and north of the road to Porter and measures



A. LOWER QUARRY OF PORTLAND-MONSON SLATE CO., MONSON, ME.

Showing lateral walls of jointed quartzite kept in place by steel and concrete brace and slate pillar (in background). This has flat joints and has been tunneled 30 feet to the next opening.



B. QUARRY OF STANDARD SLATE CORPORATION, ESMONT, VA.

Showing benches from use of channeling and undercutting machines

about 200 feet east to west, 80 feet north to south, and 170 feet in depth. (See Pl. XXVI, *B*.) Although the general structure at this place is much obscured it seems to consist of an acute syncline in the center of the quarry and an acute anticline east of it, with probably another west of it and still another syncline beyond the west edge of the quarry—in all, two synclines and two anticlines. The strike of the cleavage is N. 17°–22° E. and the dip 70° S. 80° E. The limbs of the folds strike with the cleavage and dip 50°–60° S. 80° E. There are vertical discontinuous joints striking N. 58° W. and spaced 2 to 10 feet. Another set undulates horizontally and has a spacing of 3 to 30 feet. The slate within the upper part of the central syncline on the north wall is much broken up by many open joints of the horizontal set and the slate about the lower part of this syncline abounds in shear zones (see p. 44), slip cleavage, and quartz veins. A specimen from this place shows about eight planes of slip cleavage to the inch. From the somewhat uncertain structure exposed there seems to be about 50 feet of black slate overlain by about the same thickness of green and "variegated," but in close eastward-inclined folds so that within the length of the quarry and the uncovered area west of it each bed of slate is repeated, the green five times and the black four times. As quarrying proceeds more light will be thrown on the structure.

There are four varieties of slate, as described below:

"No. 1, blue-black" (specimens D, XXXIV, 11, *a*, *d*) is of dark bluish-gray color, the bluish tint being marked and in the wet slate resembling that of specular iron. It has a very lustrous granular surface with an obscure foliation crossing the grain. It does not effervesce with acid test; the sawn edge shows pyrite; the powdered slate shows very little magnetite and still less graphite. It is sonorous and rather fissile. Under the microscope this slate shows a matrix of sericite with brilliant aggregate polarization containing on the average 2½ lenses to the square millimeter and measuring 0.25–1.12 millimeters in length and up to 0.25 millimeter in thickness. These lenses consist of carbonate, mostly in rhombs with dark-brownish content, also of chlorite, muscovite, and quartz. In sections with the cleavage these rhombs and the muscovite are radially arranged, forming brilliant objects in polarized light. The proportions of the constituents of the lenses vary greatly. In one the carbonate amounted to 50 per cent, chlorite 25 per cent, and muscovite and quartz 12.5 per cent each. The matrix abounds in minute bluish-black metallic grains of irregular size and form that are probably metallic hematite (Fe_2O_3). The carbonate is largely confined to the lenses. There are a few stains of limonite. The constituents, named in descending order of abundance, appear to be muscovite, quartz, chlorite, specular hematite, carbonate, graphite, pyrite, magnetite, rutile, tourmaline, and limonite. This is a mica slate of superior quality with a considerable content of specular hematite, to which its peculiar sheen is due. Its content of carbonate is so slight as not to appreciably affect the durability of its color. The color can not easily be confounded with that of the slates of the Arvonia district.

The "dark-green" slate (specimens D, XXXIV, 11, *e*, *k*) is of medium greenish-gray color and of lustrous, finely spangled or coarsely and sparsely granulated surface. It does not effervesce with the acid test and is sonorous. The color is devoid of the bluish tinge which marks some green slates. On exposure the color darkens somewhat.

There is also a "light-green" variety of this slate which is a dingy green. The "dark green" contains a little magnetite and the spangles are magnetite. The sawn face shows pyrite. It is very sonorous and fissile. Under the microscope this slate shows a matrix of sericite with brilliant aggregate polarization, containing lenses of chlorite, carbonate, and quartz, or of each separately with a little muscovite. The chlorite (interleaved with muscovite) lies in the grain direction, transverse to the axis of the lens. The lenses are 0.25–2 millimeters long, 0.07–0.1 millimeter thick, and 0.17–0.7 millimeter wide and average 3 or 4 to the square millimeter. The carbonate and muscovite are concentrically and radiately arranged, the carbonate being within, as seen in sections parallel to the cleavage. There are secondary (?) quartz lenses up to 1.7 millimeters wide, also scales and elongated crystals of magnetite, 0.006–0.05 millimeter wide and as much as 0.2 millimeter long, averaging about 13 to the square millimeter. Slate needles are very plentiful; a little sagenite, tourmaline, and zircon. The constituents, named in descending order of abundance, appear to be muscovite, quartz, chlorite, carbonate, magnetite, rutile, pyrite, tourmaline, and zircon. This is a mica slate with an amount of carbonate probably not large enough to affect the durability of its color appreciably.

The "variegated" slate is of purplish-gray color irregularly streaked with greenish gray, or of a peculiar very light brownish-purplish gray with meandering parallel bands ("ribbons") or beds of dark greenish gray, 0.1 to 0.3 inch wide. The banding and coloring vary greatly. The surface has but little luster and is granular. It is sonorous, does not effervesce with acid test, and has a very little magnetite and pyrite. Under the microscope this slate shows a matrix with brilliant aggregate polarization containing little beds that are less micaceous and contain more and coarser quartz and carbonate. Particles of specular hematite are plentiful but not so abundant as in the black slate. There are lenses of radiately arranged carbonate rhombs and of chlorite, 0.3 to 1.25 millimeter in diameter, in sections parallel to the cleavage and averaging nearly 2 to the square millimeter. Tourmaline, rutile needles, and limonite stains also appear. The bands are due to variations in the amount of quartz, chlorite, carbonate, and hematite. The constituents, named in descending order of abundance, appear to be muscovite, quartz, chlorite, carbonate, specular hematite, rutile, magnetite, limonite, pyrite, and tourmaline.

The "ferrous" slate, a variety of the "dark blue" which discolors on continued exposure, has dark-brownish spots and indeed a general very slight brownish tinge, both attributable to a carbonate of iron, probably also of lime and magnesia. Its surface is lustrous and granular. It effervesces slightly with acid test and is sonorous. It contains much more carbonate than the black. Its strength is reported as fair.

The following analyses of the black and green slate, made for the company by the Lehigh Testing Laboratory at Allentown, Pa., are given here for reference:

Analyses of slates from Esmont, Va.

	Dark blue.	Dark green.
Silica (SiO_2)	56.33	53.58
Alumina (Al_2O_3)	22.26	24.53
Iron oxides (FeO, Fe_2O_3)	9.44	8.81
Lime (CaO)	.68	.42
Magnesia (MgO)	1.48	1.95
Alkalies (Na_2O, K_2O)	5.07	4.88
Sulphur (S)	.004	.008
Carbon dioxide (CO_2)	1.69	1.99
Combined water (H_2O)	2.86	3.39
	99.814	99.558

The following physical tests were made by the division of tests, United States Department of Agriculture, in 1907, for the company:

Physical tests of slates from Esmont, Va.

Specific gravity	2.90
Weight per cubic foot .... pounds..	181
Water absorbed per cubic foot .... do....	0.18
Toughness	18
Crushing strength with grain .... pounds to the square inch..	19,150
Crushing strength across grain .... do....	29,500
Modulus of rupture, on a cross bending test, load at right angles to grain .... pounds to the square inch..	9,360

Machinery.—Channeling machines are used by this company for both horizontal and vertical cuts. The plant also includes a "carrier" with a continuous chain running through a trough into which the refuse slate from the cutters and splitters is thrown and is thus automatically carried to the dumps. The slate blocks are cut across the grain by circular saws, and a gang of saws is being put in to cut the large blocks obtained by channeling to the size required by the splitters.

An abandoned quarry east of Ballinger Creek and the dike and a little northeast of Esmont station is about 75 feet square and shows steep eastward-dipping cleavage.

The slate is light greenish gray and has a slightly lustrous surface, two intersecting striations, and minute dark spangles. The green is more bluish than the green slate of the Standard Slate Co.'s quarry. The sawn edge shows pyrite. Effervescence with acid test very slight. The pieces on the dumps show slip cleavage, which in this and the other quarry may possibly be related to the intrusion of the diabase.

Under the microscope this slate shows a matrix of sericite with brilliant aggregate polarization and abundant chlorite. There are lenses of chlorite and carbonate; sparsely distributed magnetite in plates; quartz and carbonate; a passage of coarser quartz, carbonate, and chlorite; an obscure plication diagonal to the cleavage.

The constituents, named in descending order of abundance, appear to be muscovite, chlorite, quartz, carbonate, and magnetite.

Snowden, Amherst County.—The slate deposit of Snowden is on the southeast side of the axis of the Blue Ridge, north of the cut through which James River flows. It is situated about 18 miles north-northwest of Lynchburg. (See map, fig. 15.) The slate crops out in a longitudinal valley between Rocky Row Mountain on the northwest and a spur of Big Piney Mountain on the southeast. It strikes N. 65° E. and is bordered by quartzite on the southeast. The general structure and the areal relations of the slate have not yet been exhaustively investigated.[1]

The only quarry in operation in 1904 was that known as the Williams Brothers slate quarry, on the property of the Virginia Slate

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[1] See Campbell, J. L. and H. D., The Snowden slate quarries: The Virginias, vol. 5, pp. 162-163, 1884. Campbell, J. L., Geology of the Blue Ridge, near Balcony Falls, Va.: Am. Jour. Sci., 3d ser., vol. 28, pp. 221-223, 1884.

Mining Co., 3 miles north-northeast of Snowden station and about 1,200 feet above it, where Rocky Row Run enters James River. Slate about 250 feet thick is exposed with a bedding strike of N. 65° E., forming a flat-topped anticline, whose northern limb dips 35° at the surface but is vertical at the bottom of the quarry and for a few feet dips steeply south, indicating a possible overturn. The cleavage strikes N. 45° E. and dips 32° SE. The bedding forms finely plicated ribbons of quartz and calcite several inches wide on the cleavage surfaces. Joints strike N. 18° E., dip 70° W., also N. 18° W., dip 65° E. The grain makes an angle of 90° to 104° with the bedding and is said to be very marked.

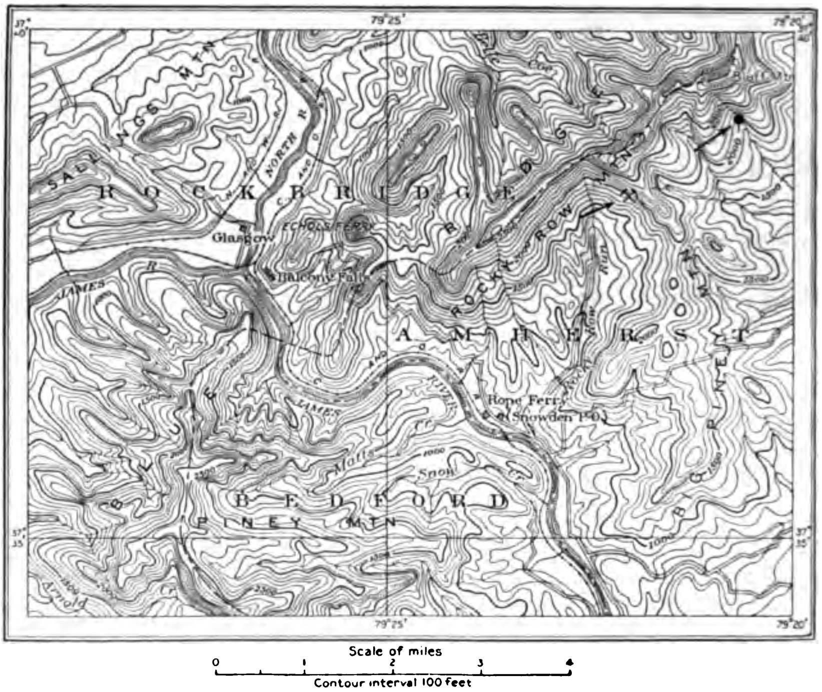

FIGURE 15.—Map showing location of slate quarries and prospects in Amherst County, Va. Quarries shown by crossed hammers; slate prospects by round dots; strike of commercial slate by arrows.

This slate is very dark gray. To the unaided eye it has a minutely granular texture and a moderately smooth cleavage surface, with very little luster. It is not graphitic, shows no pyrite on sawn edge, has no magnetite, does not effervesce with cold dilute hydrochloric acid, is fairly sonorous, has a very slight argillaceous odor, and is said not to fade.

Under the microscope it shows a matrix of muscovite (sericite), with aggregate polarization not very brilliant owing partly to the coarseness of many of the other constituents. Quartz fragments measure up to 0.08 millimeter; chlorite scales and lenses up to 0.28 millimeter in length, rarely 0.42 by 0.2 millimeter, numbering about 126 to the square millimeter; also muscovite scales up to 0.09 millimeter; some carbonate in exceedingly minute rhombs and plates; grayish carbonaceous (?) matter;

about 3,000 spherules and pyritohedrons of pyrite to the square millimeter, measuring up to 0.005 millimeter; abundant rutile needles, and scattered fragments of zircon.

The chief constituents of this slate, named in descending order of abundance, appear to be muscovite (sericite), quartz, chlorite, kaolin, pyrite, carbonate, rutile, and carbonaceous matter.

This is a superior slate, but is less crystalline than that of Arvonia. It is used exclusively for roofing, having been found less well adapted for mill stock. In 1912 this quarry was closed owing to litigation.

Thompson prospect.—About 1½ miles northeast of the Williams quarry slate was prospected in 1886 on the Thompson property, which lies on a small tributary of Otter Creek that flows into the James 1½ miles downstream from Snowden, as shown in figure 15. The thickness exposed is 20 feet; the bed strikes N. 53° E. and dips 20° S. 37° E.; the cleavage is nearly horizontal; joints strike N. 38° E. and dip 20° N. 52° W.

A reexamination of the specimens collected by the writer in 1904 shows an aggregate polarization probably obscured by lenticular texture and the distribution of carbon between the lenses as well as by the amount of carbonate. The quartz particles are noticeably angular; one detrital plagioclase; much carbonate; lamellæ of chlorite in grain direction; spherules of pyrite; abundant rutile needles.

The constituents, named in descending order of abundance, appear to be muscovite, quartz, chlorite, carbonate, carbon, pyrite, rutile, and plagioclase.

This is a mica slate, probably of the fading series, although it is asserted that slates obtained from this opening when it was made and then put on the courthouse at Amherst and on Kenmore College, in Amherst County, show no discoloration. In comparing the thin sections of this slate with those from the Williams quarry the latter are found to polarize less brightly. In sonorousness, color, and general characteristics this slate closely resembles that of that quarry.

Warrenton, Fauquier County.—There are several prospects in the neighborhood of White Sulphur Springs on the Rappahannock, 6 miles southwest of Warrenton, to which Rogers[1] referred and from which roofing slate was obtained as early as 1837. (See map, fig. 16.)

The following data afford some indications as to the geologic relations: About 1¼ miles south of the springs and 200 feet east and as far west of the road to Routsville there are outcrops of muscovitic quartzite with grains and pebbles of blue quartz up to one-fourth inch across. These beds have an apparent easterly strike and a gentle southerly dip. A little north of this point quartzite slate crops out and continues northward for 2 miles, nearly to the "colored church." Its cleavage strikes N. 25°-30° E., but the slate three-fourths of a mile south of the springs, at the river, strikes about east, like the quartzite farther south. Slate is also said to occur at points west of the road from the springs to the church. The minimum width of this slate belt is half a mile. North of the church is a greenish metamorphic eruptive consisting of actinolite, zoisite, titanite, and sericitized plagioclase. South of the quartzite are greenish schists, possibly of similar origin. Between the church and Warrenton greenish schists also crop out at several points. They are epidotic actinolite schists, in places with lenses up to 3 by 2 feet and stratiform masses of an epidotic rock containing actinolite, titanite, magnetite, chlorite, and quartz.

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[1] Op. cit., p. 460.

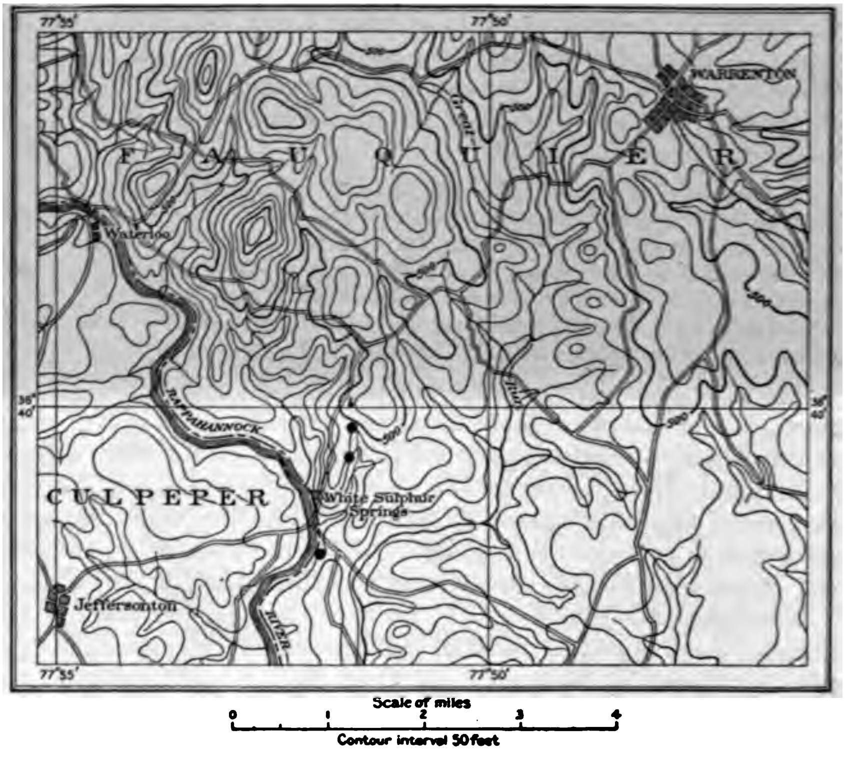

FIGURE 16.—Map of slate prospects in Fauquier County, Va. Slate prospects are shown by round dots.

All these hornblendic and epidotic rocks weather into a bright-reddish soil. This slate is thus related to a quartzitic formation, as well as to certain hornblendic and epidotic rocks, which must be regarded as metamorphosed eruptives.[1] The proximity of the slate to these other formations is so close that nothing can be assumed as to its thickness.

Slate has been prospected at three points, indicated by black dots on the map (fig. 16). One place is seven-eighths of a mile north-northeast of the springs, east of the road to Warrenton, and west of the beginning of a small brook flowing south into the Rappahannock. The cleavage strikes N. 30° E. and dips 25° W. The plowed fields on the south show a strip of dark-gray soil, from the weathering of the slate, which measures 125 feet across.

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[1] Rogers (op. cit.) refers to the epidotic rocks.

The slate is black and, to the unaided eye, has a rather coarse texture, a rough speckled cleavage surface with little luster. It is very carbonaceous, shows pyrite on sawn edges, and has about 220 cubes and lenses of pyrite to the square inch, measuring one-fiftieth of an inch and under; no magnetite; no effervescence with cold dilute hydrochloric acid. It has an argillaceous odor.

Under the microscope this shows no aggregate polarization, but a coarse cleavage, the matrix mainly of carbonaceous matter and quartz fragments with a little muscovite. The quartz grains measure from 0.009 to 0.3 millimeter; a number of plagioclase feldspar fragments up to 0.2 millimeter long. There are lenses and cubes of pyrite coated with quartz, about 4 to the square millimeter; a few scales of chlorite; rare fragments of zircon. No carbonate or rutile detected.

The chief constituents of this slate, named in descending order of abundance, appear to be carbonaceous matter, quartz, muscovite, feldspar, pyrite, and chlorite. This is a clay slate.

At a second locality about half a mile northeast of the springs, the cleavage strikes N. 25° E. and dips 20° W., and the bedding probably strikes N. 12° W. Strike joints trend N. 15° E. and dip 90°; dip joints strike N. 75° W. and dip about 90° but variable. The slate is here covered by 2 feet of black clay and 3 feet of brownish-yellow clay, both of which still show a lamination parallel to the cleavage of the underlying slate and therefore represent different stages in the decomposition of the slate.

This slate is bluish black. To the unaided eye it has a moderately fine texture and cleavage surface, with very few lenses of pyrite and but little luster. It is very carbonaceous, shows pyrite on sawn edge, has no magnetite, does not effervesce in cold dilute hydrochloric acid, is sonorous, and has an argillaceous odor.

Under the microscope this has a matrix of muscovite (sericite) with distinct aggregate polarization but abundant irregular quartz grains from 0.009 to 0.37 millimeter; also some lenses of secondary quartz, much carbonaceous matter, a few lenses of pyrite up to 0.14 millimeter, passing into limonite, and a few grains of plagioclase feldspar. No carbonate or rutile detected.

The chief constituents of this slate, named in descending order of abundance, appear to be muscovite, quartz, carbonaceous matter, and pyrite. Recent excavations are said to show a larger amount of pyrite at a depth of 20 feet than the specimen above described indicates. This is a mica slate.

The third locality is about half a mile south of the springs, on the east bank of the Rappahannock. "Slate" about 40 feet thick is exposed in a small cliff. The strike of cleavage and bedding (?) ranges from N. 80° E. to N. 85° W. and the dip from 12° to 15° S.

This slate is bluish black. It has a coarse crystalline texture and, as accurately described by Rogers,[1] a knotty, wrinkly surface. This is due to the presence of cubical and lenticular cavities once occupied by pyrite but now partly filled with quartz and graphite. These measure from one-fiftieth to three-fiftieths of an inch and number from 12 to 20 to the square inch. The surface has very little luster. The slate is carbonaceous or graphitic, shows pyrite on the sawn edge, has very little magnetite, contains in places scales of a micaceous mineral up to one twenty-fifth of an inch, does not effervesce in cold dilute hydrochloric acid, has an argillaceous odor, and is very sonorous.

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[1] Op. cit., p. 460.

Under the microscope it shows a matrix of carbonaceous or graphitic material, quartz, and muscovite. As the first two predominate the aggregate polarization is rather faint. The cleavage is serpentine, owing to the many large quartz grains (up to 0.14 millimeter) and the cubes and lenses or distorted cubes of pyrite already referred to, most of which seem to be partial pseudomorphs of quartz and graphite after pyrite, the remaining pyrite having been oxidized and dissolved. There are some grains of plagioclase feldspar almost as large as the quartz grains, with graphite inclusions parallel to the multiple twinning. Veinlets of quartz and lenses of secondary quartz occur, usually about or on either side of the cubes and lenses of pyrite; rare grains of zircon. No carbonate or rutile detected.

The chief constituents of this slate, named in descending order of abundance, appear to be carbonaceous matter and graphite, quartz, muscovite, kaolin, pyrite, and feldspar. It seems to be more metamorphic than that of the other two localities, yet to be less micaceous. This is properly a graphite-quartz-muscovite schist, or in process of becoming such.

A piece of this "slate" half an inch thick from the roof of one of the brick outbuildings at the White Sulphur Springs, where it was placed at least 75 years ago, does not show any decomposition but in places has a little limonite coating.

The pyritiferous character of the slate in all these prospects and the sulphurous character of the springs are probably intimately related. Such springs are common in the vicinity of pyritiferous shale and obtain their sulphur from the decomposition of the pyrite by surface water. The indications from the openings and the microscopic examinations are not sufficiently promising to warrant investments.

The principal features of the slate of Virginia, as given in the foregoing descriptions, will be found in tabular form opposite page 188.

WEST VIRGINIA.

The slate district near Martinsburg, in Berkeley County, W. Va., lies within the geologic belt designated Martinsburg shale in the Harpers Ferry folio of the United States Geological Survey. This belt lies about 13 miles west of the Blue Ridge and mostly on the west side of Opequon Creek, a small tributary of the Potomac. It measures at least 2 to 3 miles in width. This shale and clay slate formation, estimated at 700 to 1,000 feet in thickness, is of Ordovician age and overlies the Cambrian-Ordovician Shenandoah limestone in a series of folds represented in the folio as overturned to the west. The rock is generally a dark-grayish shale, weathering into a yellowish or white clay, known locally as "soapstone." At several points, usually near the Opequon or its tributary runs, where the mass has been denuded of its weathered zone, it has a well-marked eastward-dipping (exceptionally westward) slaty cleavage crossing the bedding at various angles, and pieces when struck with a hammer give the typical ring of a slate. The slatiness of the formation is, however, inconstant.

The now disused quarry of the Shenandoah Slate Co., about 3 miles northeast of Martinsburg, is near a small run flowing into the Opequon. In May, 1904, it measured about 100 feet along the strike, 70 feet across it, and 75 feet in depth, of which the "top" took up 25 feet. The bedding strikes N. 25° E. and dips about 15° S. 65° E. The cleavage, with the same strike, dips 75° in the same direction. There are joints striking with the cleavage and dipping 35° S. 65° E., also dip joints striking N. 50° W. and dipping 90°. The beds are small and are separated by darker ribbons. The thickest bed exposed measured 3 feet 6 inches. A diamond-drill core from a hole put down to 40 feet below the bottom of the quarry shows several 3-foot beds.

The slate is black, with a slightly brownish hue. The texture is somewhat fine and the cleavage surface roughish, without any luster whatever. The material is carbonaceous rather than graphitic, contains a little magnetite, shows pyrite on the sawn edge, effervesces with cold dilute hydrochloric acid but less in the ribbon, is somewhat sonorous, and has an argillaceous odor. Under the microscope it shows a matrix consisting of carbonate and carbonaceous matter, and therefore without aggregate polarization, but a cleavage consisting in the parallel arrangement of the carbonate and carbonaceous matter in alternating bands. A very carbonaceous bed (ribbon) crosses the cleavage at an angle of 36°. There are abundant angular quartz grains up to 0.05 millimeter; scales of chlorite interleaved with muscovite, and some of muscovite only; spherules of pyrite up to 0.01 millimeter, numbering from 6,500 to 11,000 to the square millimeter. Rutile was not observed. The amount of carbonate differs in different beds. It may be so abundant as to completely obscure the sericitic matrix. Some of the sections parallel to the cleavage show almost as much muscovite as carbonate and, curiously, a faint aggregate polarization parallel to the bedding or the grain.

The constituents of this slate, named in descending order of abundance, appear to be carbonate, muscovite (in places almost equal in amount to carbonate), quartz, kaolin, pyrite, carbonaceous matter, chlorite, and magnetite. This is a clay slate. The amount of CO_2 (carbon dioxide) in this slate was determined by George Steiger, of the United States Geological Survey, at 1.94 per cent.

An analysis of slate from this quarry, made for the company by Dr. W. C. Tilden, of Washington, shows SiO_2, 62.71; Al_2O_3, 19.40; CaO, 1.11 per cent. It was proposed to use the product of this quarry for mill stock, for which it seems better adapted than for roofing.

The following prospects were noted:

One 2 miles south of Martinsburg, on John Rowe's land, where an opening 30 by 20 feet has been made. Bedding strikes N. 32° E. and dips 60°–65° E.; cleavage strikes N. 23° E. and dips 80° E. A 3-foot bed is in sight.

Another opening has been made on the Opequon, on Light's land, half a mile south-southeast of Bedington. Bedding and cleavage strike N. 20° E., the former dipping 30° E., the latter 55° E. A 3-foot bed is in sight. Under the microscope this slate shows a faint aggregate polarization, fragments of feldspar, and rutile needles.

At an opening on T. F. Bowers's farm, about 4 miles northeast of Martinsburg, the cleavage strikes N. 27° E. and dips 73° W., but the bedding dips east. Under the microscope this also shows a faint aggregate polarization, but carbonate is unusually abundant and evidently obscures the cleavage.

In the brook on John Shedd's farm, 2½ miles south-southeast of Martinsburg, the cleavage strikes N. 20° E. Under the microscope the slate from this place shows a slight aggregate polarization and but little carbonate.

Clay slate has also been found on the McKown & Busey farm, 2 miles N. 10° W. from Middleway, in a brook 2½ miles southeast of Martinsburg, and also on land of J. W. Snyder on the Opequon, 3 miles southeast of Martinsburg, and it will be found in many other places.

Although the proportions of carbonate and muscovite vary in these slates, none of them show a complete sericitization of the matrix. They are all clay slates. The material can therefore hardly possess sufficient fissility or prove sufficiently strong or elastic to compete with mica slates for roofing. Furthermore, the amount of carbonate shown by the microscope, as well as the mode of weathering in the outcrops, indicates its probable discoloration on prolonged exposure, so that it belongs in the "fading" group of clay slates. But these characteristics do not affect its serviceableness for indoor uses.

The principal features of these West Virginia slates are stated in tabular form opposite page 188.

PART III.—ECONOMIC GEOLOGY OF SLATE.

DIFFICULTIES IN SLATE QUARRYING.

The difficulties in slate quarrying are many. Even after the commercial value and the grade of fissility of the slate itself have been fully determined by scientific and practical tests, the opening of a quarry offers serious problems. These concern the thickness of the deposit and of the weathered "top," the character of the jointing, and the presence of faults, shear zones, and dikes. There are also the practical matters of drainage, of the location of dumps, of transportation facilities, and of fuel. The cost of slate at some quarries is increased by the necessity of removing the dumps of former workings, which, for lack of capital or of good judgment, were placed on good slate. The only way to remove some of these old dumps is to throw them into the quarry on one side and hoist them up on the other. In places where the beds are steeply inclined or vertical, one of the walls falls in as the quarry deepens, and the removal of this material entails great expense. The occasional employment of a consulting engineer for the mathematical determination of the points at which supporting walls should be left would obviate mechanical accidents of this nature. (See pp. 76, 78.) The recent introduction of the method of tunneling from the slate quarries of Angers, in France, is a step in advance, as it avoids the cost of removing the "top," furnishes shelter for the workmen in winter and rain, and preserves the moisture in the exposed slate. (See pp. 114, 153.) When the tunnels attain large dimensions the French method of systematic daily inspection of marks set on the walls and roof to detect the slightest indication of any rock movement should also be adopted.[1]

There are also uncertainties of a stratigraphic nature which would be eliminated from many a slate-quarrying venture by the liberal use of the core drill.

BEDDING AND CLEAVAGE—HOW DISTINGUISHED.

Wherever the slates are traversed by "ribbons," or marked changes in color occur and persist through a thickness of several feet, or wherever strips of quartzite or limestone occur at intervals and continue longitudinally for several hundred feet, quarrymen of experience know that they have to do with beds and that the quality of the slate of any one bed may be expected to continue along that bed, unless some change should occur in the character of the cleavage. The quality of the slate is primarily dependent on the character of the sediment. This changes less frequently in a horizontal than in a vertical direction. The changes in the character of the materials brought into the sea and deposited at one time throughout a moderately large area were fewer than between those brought in at different times at any one spot. Cleavage, being the result of a later compression, may traverse sediments of slightly different composition with little change in direction but will be very much affected by great changes in the material or the grain of the sediment. (See Pl. II, *B*.) The prime factor is, then, the bed; the second factor is the cleavage.

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[1] See Larivière, G., Angers et l'Anjou, Assoc. française avanc. sci., pp. 1-51, 1903.

In the southern part of the slate belt of western Vermont, where beds of quartzite or limestone are few and inconspicuous and the difference of color is slight, the distinction between bedding and cleavage is not always easily made. Quarrymen and prospectors sometimes regard them as identical where they really differ. Where the strikes of the bedding and cleavage are divergent, if that of the cleavage is mistaken for that of the bedding, a new opening may easily be made at the wrong point and the bed looked for may be missed. (See fig. 17.) In such places the readiest means of distinguishing cleavage and bedding are as follows: (1) The fossil impressions, trails, or algæ ("wavers") are always on a bed surface; so also are crinoid stems and trilobites. (2) Minute plicated beds of quartz and calcite indicate bedding. (3) A microscopic section transverse to the cleavage, if other means fail, may indicate the amount of divergence between bedding and cleavage, as shown in Plate VII, *C*. Where both are parallel the course of the bedding may be shown by that of lenses or passages of coarser particles of quartz, carbonate, carbon, etc.

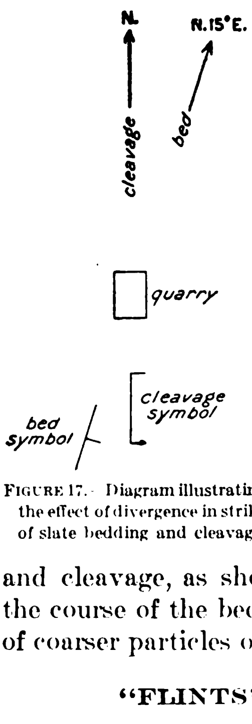

FIGURE 17.—Diagram illustrating the effect of divergence in strike of slate bedding and cleavage.

"FLINTS"—THEIR NATURE AND CAUSE.

Beds of quartzite, which may be calcareous, micaceous, or pyritiferous (see Pl. II, *A*), should never be confounded with veins of quartz (see Pl. V, *A*). In some regions they are both indiscriminately designated by the quarrymen "flints." The quartzite beds are sediments consisting mainly of quartz sand, and, although varying considerably in thickness, are generally more persistent than the quartz veins, which, as has been already shown, are chemical infiltrations into fractures produced at a much later time in consequence of various stresses. Ordinarily the quartzite has a more granular and less glassy surface than the vein quartz. A microscopic section under polarized light will almost always show the difference when ordinary means fail. The importance of not confounding the quartzite beds and the quartz veins lies in this—that while the quartzite beds indicate the direction and thickness of adjacent beds of slate and thus prove helpful, the quartz veins constitute perhaps the most fortuitous and the most pernicious element in slate quarrying. The strains which the slate masses have suffered have been so various that it is almost impossible to foretell the probable presence, course, extent, or thickness of a quartz vein. It should be noted, however, that while the fractures which occasioned the veins are to be looked upon somewhat as accidental, they are the result of stresses affecting large areas or of the complex interactions of pressure in a few definite directions. The course of a vein which is tapering out should be taken with a compass, and another should be somewhat expected in the same line or in directions parallel to it, or at nearly a right angle to it.

RELATIONS OF JOINTS, DIKES, AND SHEAR ZONES.

From the similarity in the courses of the diagonal joints and many of the dikes and shear zones in western Vermont and eastern New York there seems to be a close relation between them. They may all have been produced by the same stress at the same time, in some places the strain resulting in a "hogback," in others in a diagonal joint, and these joints, where very deep, may have given rise to dikés. The practical application of this statement is that the possibility of such a relation should lead the quarryman, whenever he finds diagonal jointing, to suspect the proximity of "hogbacks" and dikes with a similar course, and so with either a "hogback" or a diagonal dike, and this suspicion may sometimes save expenditure of time and labor.

USE OF GEOLOGIC MAP AND COMPASS IN PROSPECTING.

Although the following paragraphs refer particularly to the slate belt of western Vermont and eastern New York—and necessarily so because this is the only slate region that has been mapped by the writer in this way—the general principles and method of procedure are applicable to any slate region where the beds consist of close and more or less overturned folds.

The quarry maps, Plates XX and XXI, are designed to be of practical utility. The coloring shows where the Cambrian green and purple and the Ordovician red slates may be looked for or not looked for. The dovetailing of the Cambrian and Ordovician areas represents to a certain extent structural relations and not mere "accidents" of erosion. Thus, the Jamesville Cambrian belt is closely related to the Cambrian belt which lies east of South Granville.

On the quarry maps the course of bedding and cleavage at several quarries has been shown by special symbols. The scale of these maps is sufficiently large to admit the entry of many more quarries and symbols. By using a small geologic compass to determine the strike of any bed of good slate at any of the located quarries, and transferring the strike to the quarry map by means of a protractor, the probable direction of the recurrence of the bed can be ascertained, and so with joints, "hogbacks," or dikes. Such a compass should be provided with sights, spirit levels, and movable ring to set off magnetic variation and should have a clinometer attachment to indicate angle of dip.

Where, as at West Pawlet (see Section VII, Pl. XXII, and diagrams *A*, *B*, *C*, Pl. XXIII), the slate is closely folded, repetitions of the same series of beds may be looked for in an east-west direction at varying intervals. The possibility of the pitching of the axis of a fold in a northerly or southerly direction should be kept in mind. In such folds older or newer beds are traversed in following the direction of the pitch. Where an Ordovician belt abruptly cuts off a Cambrian belt on the north or south, the Cambrian must ordinarily be supposed to plunge under the Ordovician.

From the relations already explained, quarrymen need not be surprised, here and there, as the excavation proceeds, to come upon the Ordovician red and bright-green slates at the bottom of a "sea-green" or "unfading green" quarry, or to come upon these Cambrian slates at the bottom of a red-slate quarry (Sections I, II, V, VI, VII, Pl. XXII).

Quarrymen are very skilled in detecting the presence of good slate from the peculiar appearance of the weathered edge, and that skill appears to have been their only guide in prospecting in this region. It would be well if this skill were reinforced by the use of the following method in exploration:

1. Make reference to a geologic map for the areas in which the various slates may occur.
2. Determine on a quarry map or general map the good slate beds already exploited.
3. Make compass determination of the strike of such beds.
4. Explore along that strike.
5. Explore at right angles to that strike to see if the series is repeated by folding. (Note order of horizons in table on p. 124.)
6. Trench at promising localities across the strike to expose as large a series as possible.

7. Where surface indications are favorable, make an opening large enough to determine the angle of dip of both bed and cleavage and to obtain specimens sufficient for the tests given on pages 172–179.

8. Bore with diamond or steel-shot drill at 45° to cleavage dip, so that the core will split up into elliptical pieces sufficiently larger than diameter of core to be conveniently tested.

9. Measure thickness at right angles to bedding planes on the core.

The map of the slate district near Slatington, Pa. (Pl. XVI), upon which the quarries are carefully located and the strike and pitch shown, is also designed for practical use.

TECHNICAL DESCRIPTION OF A SLATE QUARRY.

The following outline of a description of a slate quarry is proposed as covering the features of practical geologic and economic importance, aside from the ordinary statistical matters as to amount and value of product, number of employees, etc.:

Quarry name or number.
Location (exact).
Geologic formation as given on the geologic map.
Distance from railroad and means of transporting product.
Diagram of plan of quarry to scale.
Depth of quarry.
Dimensions of working face.
Distance and direction of dumps from working face.
Means of drainage.
Number of hoists or of horse derricks.
Number of carriers.
Number of channelers.
Number of slate saws.
Capacity of air compressor.
Number of slate-trimming machines.
Kinds of slate produced.
Thickness of good and bad beds in natural order.
Diagram showing course of beds.
Strike and dip of beds.
Strike and dip of cleavage.
Bends or curvature of cleavage.
Strike and dip of strike, dip, and diagonal joints.
Curvature of joints.
Strike and dip of grain.
Strike and dip of slip cleavage.
Strike and dip of shear zones.
Location and diameter of "posts" and supports.
Proximity of dikes.
Course and thickness of veins.

METHODS OF TESTING SLATE.

Methods of testing the elasticity, absorption, fissility, and resistance of roofing slates have been in use for many years, and many more or less complete chemical analyses of slate have been published. In recent years, however, more exact methods of reaching these results have been devised. All such methods have here been brought together. If parts of one specimen, fairly representing the average quality of the product of any quarry or prospect, or if parts of each of a series of specimens, fairly representing all the different varieties and qualities there obtained, are subjected respectively to the tests described, such a slate or slates may be said to have been for all economic purposes exhaustively investigated. Several of these tests are of so simple a character as to be very easily applied. This list of methods is largely compiled from Böttinger, Fresenius, Hutchins, Jannetaz, Merriman, Reverdin and De la Harpe, Sorby, Umlauft, and J. F. Williams.[1] Although they all offer valuable suggestions, the most useful papers on the subject are those of Fresenius, Umlauft, and Merriman.

Sonorousness.—One of the first and most time-honored tests of roofing slate is to suspend a good-sized piece of the usual thinness and tap it with some hard object. If it possesses the molecular structure of a slate it will yield a semivitreous ring. A clay slate will be less sonorous than a mica slate, but mica slates with a large percentage of chlorite and possibly a little talc will be deficient in sonorousness. It is because of this property that when at the quarries refuse slates are thrown upon the dumps the sound produced is not unlike that made by the smashing of a large quantity of crockery.

Cleavability.—The test for cleavability should be applied by an experienced workman. The block should be freshly quarried, unfrozen, and moist. The chisel should be very thin and about 2 inches wide. The cost of slate is closely related to the degree of its cleavability. The cleavage face of a freshly cleft slate with a high grade of fissility usually shows extremely delicate partly detached scales of slate lying parallel with the cleavage.

Cross fracture (*"sculping"*).—This test to determine the character of the "grain" should also be applied by an experienced man to a large block several inches thick, with a stout chisel and a long-handled heavy mallet. Jannetaz[2] published a method for determining with scientific precision the direction of the grain in slate in which it is but obscurely shown on the cleavage surface. The slate is sawn in a direction parallel to its cleavage and one of the sawn surfaces is made exceedingly smooth and covered with an even and very thin coat of grease. The point of a red-hot platinum wire is applied to the slate opposite the center of the greased surface. The greased area reached by the heat will, in cooling, leave an oval outline, the long axis of which will show the direction of the grain, the heat having traveled more rapidly within the slate in the direction of the grain than in any other. He also made a disk of slate 5 inches in diameter, of ordinary thickness, with a central perforation. This disk was fastened by the extremities of the diameter parallel to the grain and afterwards by that at right angles to the grain, and was made to vibrate by tapping the side of the perforation. The sound produced when the disk was fastened by the diameter at right angles to the grain was louder than when fastened by that parallel to it. In other words, the direction of the grain was that in which elasticity and vibration were greatest.

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[1] Full titles are given in the economic bibliography, pp. 210–213.

[2] Jannetaz, E., Relation entre la propagation de la chaleur et l'élasticité sonore dans les roches, p. 417, 1877.

Character of cleavage surface.—The cleavage surface should be examined with an ordinary magnifying glass. If the grain is pronounced, it will appear in fine transverse lines. If slip cleavage, which is generally a cause of weakness, is present, it can usually be detected on the cleavage surface. Ribbons, which are sometimes lines of weakness, should be noted. There is great difference in the smoothness of the surface in slates of different regions. Ordinarily the constituent minerals ought not to be visible. Minute lenses or crystals are not necessarily detrimental, but they retain dust and thus afford a foothold for mosses and other cryptogams, which gather moisture and thus aid the decomposition of the slate.

Presence of lime.—The presence of lime can be determined by the application of cold dilute hydrochloric acid to the edges of a freshly quarried slate or still better to the powdered slate. Rapid effervescence implies the presence of carbonate of lime; slow, that of a lesser quantity of it or of dolomite—carbonate of lime and magnesia. Reverdin and De la Harpe[1] call attention to the fact that good slate may have a high percentage of calcium carbonate, while others free from it may be poor. But it is nevertheless true that slates containing a high percentage of lime must, other things being equal, in time be acted upon more powerfully by the acids of the atmosphere than those with little or no lime.

Color and discoloration.—The color of the freshly quarried slate should be noted and compared with that of pieces exposed for several years to the weather, either on a roof or on the quarry dumps, or with that at the top of the quarry close to the gravel, although this last comparison may not always be perfectly conclusive. The value of slates is somewhat affected by the extent of their discoloration.

Presence of clay.—By breathing upon a fresh and clean piece of slate and observing whether there is any argillaceous odor the presence of clay will be detected. The very best slate will not emit any such odor.

Presence of marcasite.—A slate containing lenses or crystals of a pale-yellowish metallic mineral which, on exposure, decomposes, forming a yellowish-white film and rusty spots, is poor;[1] but pyrite in small quantity is not necessarily detrimental, for it does not decompose readily. It is present in nearly all slates, particularly in black slate.

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[1] Reverdin, F., and De la Harpe, C., Chem. Zeitung, vol. 14, pp. 64-65, 94-95, 126-127.

Presence of magnetite.—Since slate has come to be used so largely in electric appliances the determination of the relative abundance of magnetite has become of practical importance. A cubic inch of the slate should be weighed, broken up, and reduced to a fine powder in an agate motor or else between sheets of zinc or copper and then spread on a flat surface and thoroughly traversed by a strong magnet and the extracted magnetite weighed. The quantity of magnetite, by weight, in a cubic inch of slate can thus be determined.

Electric resistance.—The electric resistance of slate is governed in part by the scarcity of magnetite and in part probably also by the character of bedding, cleavage, and grain. The tests applied by Prof. W. N. Gladson, of the University of Arkansas, to Arkansas slates can be used. The object of these tests is to determine the adaptability of the slate for electric switchboards.

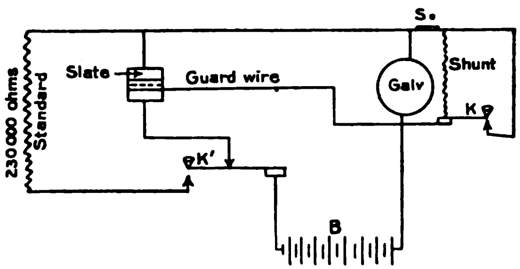

FIGURE 18.—Diagram showing electric connections made in testing slate, by W. N. Gladson.

The following description of these tests is taken from a report by Purdue:[2]

> These pieces of slate were tested in comparison with three pieces of gray slate taken at random from old switch bases in the university electric laboratory. A piece 1 centimeter cube was cut from each sample and these were numbered consecutively from 1 to 9, Nos. 1, 3, and 4 being gray slate. In preparing the cubes metallic particles were found in samples 4 and 6, and Nos. 5 and 6 were so easily split that it was difficult to obtain a centimeter cube.
>
> The pieces of red slate as received were smooth blocks 4 by 5 inches by five-eighths of an inch, neither varnished nor in any way filled. They were red or reddish brown, were much softer than the gray slate, and split much more readily. All samples tested were dry and appeared to be seasoned. The method of measuring the resistance of these centimeter cubes was as follows:
>
> A block of paraffin wax was attached to the center of a glass plate, which in turn was thoroughly insulated from the table by glass strips piled across one another. In the top of the paraffin block an opening was cut 1 centimeter square and about 3 millimeters deep. In the bottom of the cavity thus formed four copper supports were embedded so that their top surfaces were in the same plane, about 1 millimeter below

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[1] See Julien, A. A., On the variation of decomposition in the iron pyrites; its cause, and its relation to density: New York Acad. Sci. Annals, vol. 3, pp. 365-403, 1886; vol. 4, pp. 125-221 and Pls. VIII, IX, 1887. Brown, A. P., On marcasite and pyrite; a comparative study of the chemical behavior of pyrite and marcasite: Am. Philos. Soc. Proc., vol. 33, pp. 225-243, 1894. Stokes, H. N., On pyrite and marcasite: U. S. Geol. Survey Bull. 186, 1901.

[2] Purdue, A. H., The slates of Arkansas: U. S. Geol. Survey Bull. 430, pp. 329-330, 1910.

the top of the paraffin cup. A drop of mercury coming about flush with the copper supports in this cavity formed one terminal for making electric connection to the slate cube. Contact with the opposite face was made by placing a well-amalgamated zinc plate 1 centimeter square on top of the cube. This arrangement insured equal contact with each slate cube under test.

The galvanometer used was of the D'Arsonval type and had a working constant of 70,533 millimeters on the scale 1 meter distant through 1 megohm resistance. The electromotive force was furnished by storage cells and was kept constant at 42 volts during the experiment. The connections were made as shown in figure 18.

To avoid leakage over the surface of the slate a guard wire was connected as shown. All readings were taken after the deflections became constant; in some tests they did not become so until half an hour after electrification.

The results of the test are shown in the following table, from which we find the average resistance of all samples to be 1,224.2 megohms per cubic centimeter. The average resistance of the three gray samples was 1,180, and of the six red-slate samples 1,267.8 megohms per cubic centimeter. Each piece tested, except No. 7, shows a different resistance between each pair of opposite parallel faces, which seems to depend on the plane of cleavage. The gray-slate samples show a decidedly higher resistance between faces of cubes perpendicular to cleavage planes, but in individual samples the distribution of resistance would be greatly affected by the presence of foreign conducting particles or seams, which are likely to be present in all slate.

Results of tests of electric resistance of samples of slate from Arkansas.

Sample No.	Galvanometer scale deflections.			Resistance.[a]		
	Perpendicular to cleavage planes.	Parallel to cleavage planes.		Perpendicular to cleavage planes.	Parallel to cleavage planes.	
	D	D′	D″	R	R′	R″
	Mm.	*Mm.*	*Mm.*	*Megohms.*	*Megohms.*	*Megohms.*
1	39.0	40.0	44.0	1,808.5	1,763.3	1,603.0
2	98.0	174.0	625.0	719.7	405.3	67.1
3	171.0	185.0	283.0	414.9	381.2	249.2
4	35.0	94.0	43.0	2,015.3	750.4	1,640.3
5	104.0	47.7	39.9	678.2	1,476.3	1,767.1
6	338.9	28.0	88.0	208.1	2,519.0	801.5
7	91.0	91.0	48.0	775.0	775.0	1,469.4
8	57.0	51.0	27.0	1,500.7	1,383.0	2,612.3
9	45.0	33.0	36.0	1,567.4	2,137.3	1,959.2

[a] R, R′, and R″ correspond to the directions D, D′, and D″, respectively.

Average of Nos. 1, 3, and 4 (gray slate), 1,180.6 megohms per centimeter cube.
Average of Nos. 2, 5, 6, 7, 8, and 9 (red slate), 1,267.8 megohms per centimeter cube.
Average of all samples, 1,224.2 megohms per centimeter cube.

Strength.—Merriman's apparatus for testing the strength of slate is described in his paper:[1]

> The pieces were supported in a horizontal position upon wooden knife-edges 22 inches apart, and these loads were placed upon another knife-edge halfway between the supports. This load was applied by means of sand running out of an orifice in a box

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[1] Merriman, Mansfield, Am. Soc. Civil Eng. Trans., vol. 27, Nos. 3 and 6, 1892; vol. 32, pp. 529–539, 1894. An extended abstract of Merriman's paper is given by W. C. Day in part 6, continued, of U. S. Geol. Survey Nineteenth Ann. Rept., pp. 257–263, 1898. On p. 182 of this bulletin the results of his recent tests of 33 specimens of slate are given.

at the uniform rate of 70 pounds per minute, and by the help of an electric attachment the flow was stopped at the instant of rupture.

He computes the modulus of rupture by the use of the formula $S=\frac{3wl}{2bd^2}$, in which w is the load in pounds which causes the rupture, l the distance between the supports in inches, b the breadth, and d the thickness of the plate in inches. S is the number of pounds to the square inch. According to these tests the modulus of rupture in the best slate should range from 7,000 to 10,000 pounds.

J. F. Williams[1] made tests of compression and elastic limit on purple, red, and green slates from Rutland and Washington counties. His results give a modulus of rupture ranging from 7,310 to 10,800 pounds to the square inch. Campbell and Donald[2] give 20,000 pounds as the crushing weight for 1 cubic inch of slate. Wilkinson, in his "Practical geology of Ireland," gives 30,730 pounds as the crushing weight of the Killaloe slates.[3] Watrin[4] gives the maximum crushing weight of some French slates as 2,000 kilograms to the square centimeter, but 1,700 as the average.

Merriman has also devised an impact test for determining the strength of slates. He lets a wooden ball weighing 15.7 ounces fall 9 inches upon a piece of slate measuring 6 by 7¾ inches and from 0.20 to 0.28 inch thick, and repeats the blows until the slate breaks. The foot-pounds of work to the pound of slate are then calculated from the weight and thickness of the slate and the number of blows. The resulting figures range from 3.50 to 126.66.

Toughness or elasticity.—Merriman finds the ultimate deflection in certain Pennsylvania slates, when placed on supports 22 inches apart, to range from 0.270 to 0.313 inch. Certain blue-black slates of Eldorado County, Cal., when split seven to the inch and 18 inches square and fastened solidly at the two ends are said to bend 3 inches in the center without any sign of fracture.[5] J. F. Williams[1] tested beams of slate from Rutland and Washington counties, 1 inch square and 10 inches long, with supports 6 inches apart. Bending without breaking was effected by a pressure of 770 to 1,200 pounds, and when the supports were placed 3 inches apart by 1,710 to 2,400 pounds. The great elasticity of the slates of western Vermont and of Northampton and Lehigh counties, Pa., is apparent to anyone visiting the shanties where the splitting is done.

Density or specific gravity.—The specific gravity is determined in the usual way, by weighing a piece of the slate in and out of water and dividing its weight out by the difference between its weight in and out. All air should first be removed by boiling the piece of slate in distilled water. The specific gravity will be considerably affected by the amount of magnetite or pyrite.

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[1] Van Nostrand's Eng. Mag., vol. 31, pp. 101-103, 1884.

[2] Encycl. Brit., 9th ed., 1887.

[3] Quoted by Hull, Edward, A treatise on the building and ornamental stones of Great Britain, etc., 1872.

[4] Watrin, N., Les ardoisières des Ardennes, pp. 192, 193, 1898.

[5] Crawford, J. J., California State Min. Bureau, Twelfth Rept., p. 400, 1894.

Porosity.—The porosity is best determined by drying, then weighing, then immersing for 24 hours and weighing again, in order to ascertain the percentage of water absorbed. Merriman takes a piece 3 by 4 inches, with rough edges, dries it in an oven at 135° F. for 24 hours, cools to the normal temperature of the room, weighs, immerses it for 24 hours, and weighs again. His tests of Pennsylvania slates showed from 0.099 to 0.303 per cent of absorption. Porosity is sometimes roughly indicated by immersing a roofing slate edgewise one-half in water and observing how far the water ascends by capillary attraction. In good slates it ought to rise but very little.

Reverdin and De la Harpe[1] state that slates are liable to deterioration from the chemical action of gases arising from woodwork beneath the slate, as well as from the action of the atmosphere, and that they are also liable to an increase of porosity by the physical action of changes of temperature and by the unequal conductivity of heat in the direction of cleavage and of grain. They state that the porosity in a fresh slate should be below 0.1 per cent, or after treatment less than 0.2 per cent. Their somewhat elaborate method is this: For determining porosity as produced by acids the slate is treated with 10 per cent cold acetic acid and the flask is made vacuous from time to time. The piece is then washed, dried, weighed, and immersed in diphenylamine in a thick-walled tube 12 by 3½ centimeters. The tube is exhausted and then heated two hours in an oil bath at 170° C., air pressure is restored, and heating is continued for four to five hours at 150° C., after which the test pieces are removed, the diphenylamine wiped off with ether, and the increase in weight taken.

For determining porosity as produced by changes of temperature, the slate is heated in a wrought-iron tube for half an hour to 300° C., and the tube is then suddenly cooled by a stream of water for half an hour. This process is repeated 24 times, and the slate is then impregnated with diphenylamine and the procedure is as in the previous test.

Fresenius is accredited with a method of testing the effect of heat and cold on slate by saturating it with water and putting it for 24 hours in a freezing mixture and heating another piece from 250° to 350° for five or six hours and then immersing it in water. The porosity, strength, and elasticity of the pieces so treated should then be tested. Böttinger points out that the greater the porosity of a slate the more damaging is the action of frost likely to be. The effect of frost on the microscopic structure has already been referred to (p. 35).

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[1] Op. cit.

Hardness or abrasion.—Merriman has also devised a method of testing the relative hardness of slates by subjecting a piece of determined weight to the action of a grindstone revolved 50 times, the slate being held against it by a lever with a constant pressure of 10 pounds. The loss of weight in the process was then determined. As the softness depends largely upon the amount of quartz and mica, a microscopic analysis would also throw light upon this quality.

Corrodibility.—An important quality in roofing slates is their resistance to the acids of the atmosphere, particularly in cities, where gases increase the destructive power of these acids. Fresenius in 1868 suggested testing the weathering qualities of a slate by immersing it for three days in dilute sulphurous acid in a closed vessel. At the end of that time poor slates are softened or broken up into thin laminæ or easily fractured, but good ones preserve both their density and hardness.

Merriman for the same purpose prepared a solution consisting of 98 parts of water, 1 part of hydrochloric acid, and 1 part of sulphuric acid. Pieces of slate 3 by 4 inches were carefully weighed, then immersed in the solution for 120 hours, then dried for 40 hours, weighed, the solution strengthened, and the pieces reimmersed for another 120 hours and weighed again. This was repeated once more. The losses in weight ranged from 0 to 2.76 per cent.

Microscopic analysis.—One of the most satisfactory tests of slate is the examination of a thin section of it under the microscope. A cubic inch thus tested will suffice to show the character of the cleavage, the presence of slip cleavage, if any, the probable durability or non-durability of the color, as well as the presence of any mineral constituents likely to determine its other qualities. The specimen should be carefully selected, so as to fairly represent the general quality of the bed. It should be fresh, unfrozen, and half an inch thick across the cleavage. At least two sections should be prepared—although the more the better—one parallel to the cleavage and another at right angles to it, never diagonal to it. The sections should be exceedingly thin, much thinner than ordinary sections of eruptive rocks, and the slide cover should be of the very thinnest kind and should be fastened on with a minimum of balsam to admit the use of the highest objectives. Both slides should be examined first in ordinary light and then in polarized light, with powers ranging from 140 to 700 or even 1,100 diameters. The transverse section will show the quality of the cleavage, the slip cleavage, if any, and, under polarized light, whether the specimen is a mica slate or a clay slate, by the entire matrix becoming in a mica slate four times dark and four times light in complete rotation. The observer should not be misled, however, by the obscuration of aggregate polarization caused by the abundance of carbonaceous matter or carbonate or hematite. The carbonate, which extinguishes irregularly, is very troublesome. It could be eliminated by the application of hydrochloric acid to the bare section and then re-covering it. The aggregate polarization may also be obscured by the thickness of the section and the whole analysis thus vitiated. Sections parallel to the cleavage reveal the amount of carbonate and indicate the probable amount of discoloration by exposure. Both sections, under incident light, will show pyrite, if any exists. If the carbonate contains no ferrous carbonate a thin section cut parallel to the cleavage of a long-exposed roofing slate and ground down almost entirely from the back so as to bring the exposed surface next to the slide will show the carbonate free from brownish discoloration.

The following passage translated from an abstract of J. Hirschwald's exhaustive work on the testing of building stones,[1] will be found useful in the microscopic examination of roofing slate:

> The microscopic examination of roofing slates, which is best made with sections at right angles to the cleavage, shows that the textural variations of slate depend mainly on the development of the mica layers. The mica itself either occurs in thick-leaved lamellæ of dark color with the optical properties of biotite (magnesia mica) or it appears faint yellowish to colorless and then always makes up fine scaly aggregates, but sometimes very much streaked thin lamellæ. The scaly aggregates resemble phlogopite (the ironless magnesia mica); the streaked lamellæ resemble sericite (fibrous muscovite). Besides these there are chloritic varieties. Some of the mica is of uniform color, and some spotted to opaque. This may be due to magnetite or to coaly matter. In the latter case the black spots are not sharply bounded, but have merging outlines and this is also true of the general outline of the mica lamellæ when strongly impregnated with coal. If the mica is in continuous layers, as it usually is in the good slates, it prevents access of water from the surface. It not only protects the other constituents that lie between the mica layers from the dissolving, softening, and decomposing effect of water, but the inner part of the slightly dampened slate is not as much exposed to the action of frost as it would be in slates greatly saturated with water. When the mica is less abundant it makes up discontinuous layers or in the inferior slates quite separate little lamellæ. These admit water freely from the cleavage face and consequently more solution takes place, more decomposition of any content of pyrite, and especially more frost action. Those slates that contain mica in separate scales, even where continuous mica layers have been developed, show an increased absorption and thus greater evidence of decomposition, and are therefore among the least valuable slates.
>
> But there is still another difference in the development of the mica layers. In some slates these possess a remarkable parallelism of arrangement; in others they are more or less fibrous, the mica enveloping the other constituents in lenses, and in this way a close connection is brought about at short intervals between the separate mica layers. In the slates of the first type, water gains free access laterally from the edge of each slate by capillary attraction and distributes itself between the mica layers, and such slates easily scale under the action of frost. But in the slates of fibrous texture such lateral admission of water can occur only to a very slight extent, and as the

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[1] Zeitschr. prakt. Geologie, vol. 16, pp. 387-389, 1908.

continuous and mostly well-developed layers of mica prevent the entrance of water from the cleavage surface any considerable frost action is shut out. When, after the lapse of centuries, such fibrous slates finally weather they show but little exfoliation and in many cases only scaly disintegration. Very micaceous slates of fibrous texture are among the best roofing materials if their mica is in homogeneous layers and not in the loose scaly aggregates above described.

But slates poor in mica may be tolerably durable if they are strongly silicified. The clayey material thus acquires considerable hardness and affords a corresponding resistance to the softening effect of water.

Coaly slates belong in a special class. In some the coaly substance is only interleaved with the mica layers, which, under the microscope, appear intensely black and opaque and have peculiar intergrown borders, while the other constituents are quite transparent. In others the coaly matter is distributed either evenly or in single irregularly disseminated spots throughout the slate mass. All coaly varieties of slate are inferior, because the coal is hygroscopic and thus opens the mica layers so that they fail to protect the intervening matter from the operation of water. As stated, the black inclusions may also consist of magnetite, which does not possess the deleterious property of the coaly constituent. As both of these substances and the usually associated pyrite are equally opaque it is important when other means fail to distinguish them microscopically. The simplest way is to examine the section under incident light, preferably lamplight. The coaly matter will then appear intensely black, the magnetite bright gray with metallic luster, but the pyrite a bright golden yellow. This method is also serviceable in distinguishing the other constituents of slate, as, for instance, quartz and feldspar. The quartz is water clear, but the feldspar is more or less cloudy according to its degree of decomposition.

The above extract is an important supplement to the microscopic notes in this bulletin. Although some of the slates described probably differ from the American slates, they may yet be found here, and the observations are discriminate and the methods suggestive.

Chemical analysis.—In order to give a correct idea of the composition of the slate, the chemical analysis should not be partial but complete.[1] Such analysis should then be compared with complete analyses of the best slates of like color. Its microscopic analysis and the results of the tests of its strength, elasticity, porosity, and corrodibility should be considered in connection with its chemical analysis. Merriman[2] concludes from six different kinds of tests applied to each of 24 specimens of slates from the "Old Bangor" and Albion quarries of Pennsylvania, as well as from the results of several general chemical analyses, that—

The strongest slate stands highest in weathering qualities, so that a flexural test affords an excellent index of all its properties, particularly if the ultimate deflection and the manner of rupture be noted. The strongest and best slate has the highest percentage of silicates of iron and alumina, but is not necessarily the lowest in carbonates of lime and magnesia. Chemical analyses give only imperfect conclusions regarding the weathering qualities of slates and do not satisfactorily explain their physical properties.

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[1] See, on the advantages of complete analysis, Hillebrand, W. F., Principles and methods of analysis applied to silicate rocks: U. S. Geol. Survey Bull. 148, pp. 1-64, 1897; The analysis of silicate and carbonate rocks: U. S. Geol. Survey Bull. 422, 1910.

[2] Op. cit.

As the discoloration in slate has been shown to be probably due to the oxidation of the ferrous carbonate ($FeCO_3$), one of the chief objects of a chemical analysis should be to show the amount or absence of the carbonate, but this is just what a chemical analysis can not do with so complex a rock. It rarely happens that the chemical analysis of a slate affords conclusive evidence as to its commercial value. The value of such analysis is quite subsidiary to that of the microscopic examination. This was practically demonstrated in the West Virginia clay slate district, where investments were made and a quarry was opened largely on the basis of a chemical analysis, and what could have been learned from the study of a few thin sections was not ascertained until it was too late.

Hutchings[1] finds that the presence of chlorite minerals can be detected by heating the slate to dull redness, thus dehydrating and discoloring those minerals, then preparing a thin section of the slate so treated and comparing it with sections of the normal rock.

The most decisive of all these tests are probably those for strength and toughness, as applied by Merriman, and the microscopic analysis.

It should be added that shearing, compression, and expansion tests of slate were formerly made at the United States Arsenal at Watertown, Mass., and that transverse and absorption tests are now made by the United States Bureau of Standards. (See p. 189.)

TESTS OF CERTAIN MAINE, NEW YORK, PENNSYLVANIA, VERMONT, AND VIRGINIA SLATES.

By Mansfield Merriman.

Physical tests of some of the slates described in this bulletin were made for the United States Geological Survey at Lehigh University, South Bethlehem, Pa., in 1905.

The following is a report of the results of the tests of 33 specimens of roofing slate received at our laboratory from May 6 to May 13, 1905. The tests have been made according to the methods described in my paper on "The strength and weathering qualities of roofing slates."[2]

All the specimens were 12 by 24 inches in size. The following is a statement of the marks placed upon them and of their mean thicknesses:

C1, C2, C3, C4 designate four blue slates from the Chapman Slate Co., Chapman quarries, Pennsylvania, the mean thicknesses being 0.228, 0.204, 0.216, 0.222 inch, respectively.

W1, W2, W3, W4 designate four blue slates from the Williams Slate Co., Arvonia, Va., the mean thicknesses being 0.202, 0.195, 0.206, 0.263 inch, respectively.

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[1] Hutchings, W. M., Clays, shales, and slates: Geol. Mag., dec. 4, vol. 3, Nos. and 8, 1896.

[2] Am. Soc. Civil Eng. Trans., September, 1892.

P1, P2, P3, P4 designate four blue slates from A. L. Pitts, Arvonia, Va., the mean thicknesses being 0.232, 0.200, 0.204, 0.194 inch, respectively.

B1, B2, B3 designate three blue slates from the Merrill Brownville Slate Co., Brownville, Me., the mean thicknesses being 0.220, 0.195, 0.210 inch, respectively. A fourth piece sent by this firm was accidentally broken.

Mo1, Mo2, Mo3, Mo4 designate four blue slates from Monson Consolidated Slate Co., Monson, Me., the mean thicknesses being 0.238, 0.227, 0.237, 0.225 inch, respectively.

V1, V2 designate two green slates from Vermont Unfading Green Slate Co., Fair Haven, Vt., the mean thicknesses being 0.222, 0.262 inch, respectively. Two other pieces sent by this firm were found broken in the package.

R1, R2, R3, R4 designate four green slates from Rising & Nelson Slate Co., West Pawlet, Vt., the mean thicknesses being 0.260, 0.167, 0.224, 0.213 inch, respectively.

M5, M6, M7, M8 designate four green slates from Mathews Consolidated Slate Co., Boston, Mass., the mean thicknesses being 0.194, 0.222, 0.187, 0.205 inch, respectively. The labels on these slates were marked "Quarry N. E."

M1, M2, M3, M4 designate four red slates from Mathews Consolidated Slate Co., Boston, Mass., the mean thicknesses being 0.190, 0.180, 0.174, 0.186 inch, respectively. The labels on these slates were marked "Quarry E."

The following table gives the results of the tests of the 33 specimens for strength, toughness, density, softness, porosity, and corrodibility, and also the means for each of the nine different kinds of slate:

Tests of roofing slates.

Color and firm.	Mark on specimen.	Strength—modulus of rupture in pounds to the square inch.	Toughness—ultimate deflection in inches on supports 22 inches apart.	Density—specific gravity.	Softness—amount in grams abraded by 50 turns of a small grindstone.	Porosity—per cent of water absorbed in 24 hours.	Corrodibility—per cent of weight lost in acid solution in 63 hours.
Blue;[a] Chapman Slate Co...	C1.......	8,410	0.21	2,775	0.171	0.221	0.336
	C2.......	12,490	.24	2.780	.218	.290	.301
	C3.......	7,420	.16	2.734	.234	.150	.560
	C4.......	9,540	.24	2.766	.213	.263	.334
	Mean....	9,460	.212	2.764	.208	.231	.383
Blue;[b] Williams Slate Co...	W1......	8,590	.17	2.788	.073	.105	.281
	W2......	8,250	.19	2.754	.038	.090	.401
	W3.....	10,700	.31	2.795	.097	.209	.223
	W4.....	8,620	.24	2.788	.033	.167	.270
	Mean....	9,040	.227	2.781	.060	.143	.294

[a] Designated "very dark gray" in table opposite page 188.
[b] Designated "very dark greenish gray" in table opposite page 188.

Tests of roofing slates—Continued.

Color and firm.	Mark on specimen.	Strength—modulus of rupture in pounds to the square inch.	Toughness—ultimate deflection in inches on supports 22 inches apart.	Density—specific gravity.	Softness—amount in grams abraded by 50 turns of a small grindstone.	Porosity—per cent of water absorbed in 24 hours.	Corrodibility—per cent of weight lost in acid solution in 63 hours.
Blue;[a] A. L. Pitts	P1	8,540	0.25	2.805	0.095	0.332	0.248
	P2	9,010	.18	2.790	.159	....	.552
	P3	11,970	.25	2.788	.138	.154	.275
	P4	9,880	.22	2.781	.038	.163	.218
	Mean	9,850	.225	2.791	.108	.216	.323
Blue;[b] Merrill Brownville Slate Co	B1	8,860	.17	2.790	.243	.189	.366
	B2	9,050	.21	2.804	.360	.128	.284
	B3	11,720	.22	2.799	.192	.128	.264
	Mean	9,880	.200	2.798	.265	.148	.305
Blue;[b] Monson Consolidated Slate Co	Mo1	9,500	.24	2.796	.234	.181	.282
	Mo2	11,370	.22	2.795	.302	.181	.384
	Mo3	7,000	.19	2.794	.271	.206	.234
	Mo4	8,640	.17	2.791	.218	.186	.243
	Mean	9,130	.205	2.794	.256	.188	.286
Green; Vermont Unfading Green Slate Co	V1	6,250	.19	2.783	.326	.300	.277
	V2	6,580	.26	2.759	.356	.162	.313
	Mean	6,410	.225	2.771	.341	.231	.295
Green; Rising & Nelson Slate Co	R1	6,790	.24	2.750	.184	.429	.433
	R2	11,040	.22	2.740	.183	.220	.722
	R3	3,470	.13	2.733	.209	.365	1.067
	R4	7,700	.24	2.700	.185	.286	.849
	Mean	7,250	.207	2.736	.190	.325	.768
Green;[c] Mathews Consolidated Slate Co	M5	7,090	.22	2.783	.286	.376	.413
	M6	5,470	.15	2.782	.203	.409	.265
	M7	10,130	....	2.786	.244	.360	.428
	M8	9,490	.20	2.781	.172	.351	.409
	Mean	8,050	.190	2.783	.226	.374	.379
Red; Mathews Consolidated Slate Co	M1	6,850	.18	2.834	.069	.153	.249
	M2	9,870	.27	2.853	.099	.251	.425
	M3	11,340	.25	2.853	.119	.334	.507
	M4	8,820	.23	2.853	.304	.235	.311
	Mean	9,220	.232	2.848	.148	.243	.373

[a] Designated "very dark greenish gray" in table opposite page 188.
[b] Designated "very dark gray" in table opposite page 188.
[c] Designated "bright green" in table opposite page 188.

The results given, with the exception of those for softness, may be compared with the results for the slates of the Bangor, Pen Argyl, Lehigh, and Peach Bottom districts, given in my papers published in Transactions of the American Society of Civil Engineers for September, 1892, and December, 1894, and in Stone for July, 1898. The results above given for softness are comparable with one another, but can not be compared with those in the papers cited; this is due to the circumstance that the former grindstone has been destroyed by fire and that the one selected to replace it has a much smaller abrading capacity.

TESTS OF SLATES FROM ARKANSAS.

Specimens of slates from Arkansas, collected by Prof. A. H. Purdue, were subjected to various physical tests at the United States Geological Survey laboratory at St. Louis. The results of these tests, published in Survey Bulletin 430, are repeated here for reference.

Source and color of slate samples tested.

No.	Owner.	Locality.	Color.
1	Southwestern Slate Mfg. Co.	East line of NE. ¼ SE. ¼ sec. 33, T. 3 S., R. 27 W.	Red.
2	do.	do.	Green.
3	M. J. Harrington	Sec. 24, T. 3 S., R. 29 W.	Black.
4	Southwestern Slate Co.	SE. ¼ SE. ¼ sec. 33, T. 3 S., R. 27 W.	Red.
5	M. J. Harrington	Sec. 24, T. 3 S., R. 29 W.	Black.
6	M. W. Jones	do.	Green.
7	do.	do.	Do.
8	do.	do.	Red.
9	do.	do.	Reddish brown.
10	do.	do.	Red.
11	C. B. Baker	NE. ¼ sec. 18, T. 3 S., R. 28 W.	Buff.
13	M. W. Jones	Sec. 24, T. 3 S., R. 29 W.	Red.

Results of physical tests on slates from Arkansas.

Field No.	Register No.	Individual specimen No.	Transverse tests.							Absorption tests.						Specific gravity.		Absolute porosity.[a]	Weight per cubic foot.
			Dimensions.		Span.	Conditions at maximum load.			Modulus of elasticity (constant nearly to maximum).	Weight ratio of absorption.			Volume ratio of absorption.						
			Width.	Depth.		Load at center.	Deflection at center.	Modulus of rupture.		30 minutes.	24 hours.	48 hours.	30 minutes.	24 hours.	48 hours.	True.	Apparent.		
			Inches.	*Inches.*	*Inches.*	*Pounds.*	*Inches.*	*Lbs. per sq. inch.*											*Pounds.*
1	Misc. 141.....	1	2.00	0.95	9	322	0.0190	2,410	2,100,000	0.0017	0.0189	0.0189	0.0047	0.0511	0.0513	2.863	2.714	....	169.1
		2	1.98	.97	9	674	.0148	4,880	4,640,000	.0005	.0175	.0193	.0014	.0475	.0523	2.859	2.712	....	169.0
		3	1.98	.98	9	854	.0196	6,060	4,250,000	.0011	.0164	.0786	.0031	.0439	.0500	....	2.689	....	167.5
	Average...	....	....	....	....	....	....	4,450	3,660,000	.0011	.0176	.0189	.0031	.0475	.0512	2.861	2.705	0.0545	168.5
2	Misc. 141.....	1	1.94	1.00	9	920	.0134	6,400	6,430,000	.0004	.0089	.0105	.0010	.0243	.0286	2.813	2.738	....	170.6
		2	1.97	.98	9	959	.0150	6,840	6,040,000	.0004	.0075	.0095	.0012	.0205	.0260	2.816	2.747	....	171.1
		3	1.99	.97	9	920	.0170	6,630	5,470,000	.0003	.0087	.0101	.0009	.0238	.0276	....	2.744	....	171.0
	Average...	....	....	....	....	....	....	6,620	5,980,000	.0004	.0084	.0100	.0010	.0229	.0274	2.815	2.743	.0256	170.9
3	Misc. 143.....	1	1.98	.28	12	59	.0430	6,840	13,420,000	.0037	.0160	.0189	.0094	.0409	.0481	2.696	2.550	....	158.9
		2	1.95	.26	12	56	.0790	7,640	8,820,000	.0012	.0114	.0146	.0031	.0293	.0375	2.702	2.564	....	159.7
		3	2.05	.27	12	80	.0855	9.640	11,030,000	.0041	.0167	.0201	.0105	.0425	.0512	....	2.544	....	158.5
	Average...	....	....	....	....	....	....	8,040	11,090,000	.0030	.0147	.0179	.0077	.0376	.0456	2.699	2.553	.0541	159.0
4	Misc. 144.....	1	2.07	.30	12	93	.0600	8,990	11,820,000	.0026	.0113	.0121	.0072	.0310	.0332	2.862	2.748	....	171.2
		2	1.98	.27	12	64	.0560	7,980	12,420,000	.0009	.0087	.0114	.0025	.0241	.0315	2.857	2.776	....	173.0
		3	1.99	.29	12	80	.0615	8,600	11,570,000	.0013	.0112	.0122	.0086	.0307	.0334	....	2.741	....	170.8
	Average...	....	....	....	....	....	....	8,520	11,940,000	.0016	.0104	.0119	.0044	.0286	.0327	2.860	2.755	.0367	171.7
5	Misc. 145.....	1	1.94	.85	12	210	....	2,700	2,900,000	.0023	.0120	.0157	.0058	.0305	.0402	2,705	2.557	....	159.3
		2	2.04	.77	12	279	.0405	4,150	3,150,000	.0033	.0153	.0193	.0083	.0390	.0491	2.704	2.544	....	158.5
		3	1.94	.78	12	388	.0335	5,920	6,010,000	.0094	.0121	.0156	.0062	.0309	.0397	....	2.553	....	159.1
	Average...	....	....	....	....	....	....	4,260	4,020,000	.0027	.0131	.0169	.0068	.0335	.0430	2.705	2.551	.0570	159.0

[a] Apparent specific gravity + true specific gravity.

Results of physical tests on slates from Arkansas—Continued.

Field No.	Register No.	Individual specimen No.	Transverse tests.							Absorption tests.						Specific gravity.		Absolute porosity.[a]	Weight per cubic foot.
			Dimensions.		Span.	Conditions at maximum load.			Modulus of elasticity (constant nearly to maximum).	Weight ratio of absorption.			Volume ratio of absorption.						
			Width.	Depth.		Load at center.	Deflection at center.	Modulus of rupture.		30 minutes.	24 hours.	48 hours.	30 minutes.	24 hours.	48 hours.	True.	Apparent.		
			Inches.	*Inches.*	*Inches.*	*Pounds.*	*Inches.*	*Lbs. per sq. inch.*											*Pounds.*
6	Misc. 146.....	1	2.04	1.09	12	400	.0252	2,970	2,620,000	0.0014	0.0076	0.0114	0.0040	0.0210	0.0314	2.860	2.771	....	172.6
		2	2.03	1.02	12	318	.0134	2,710	4,810,000	.0010	.0081	.0093	.0027	.0225	.0257	2.854	2.767	....	172.4
		3	2.03	1.01	12	791	.0233	6,880	6,920,000	.0015	.0080	.0093	.0041	.0221	.0257	....	2.769	....	172.5
	Average...	....	....	....	....	....	....	4,190	4,780,000	.0013	.0079	.0100	.0036	.0219	.0276	2.857	2.769	.0308	172.5
7	Misc. 147.....	1	2.03	.24	12	35	.0660	5,390	9,240,000	.0010	.0089	.0109	.0028	.0243	.0300	2.805	2.739	....	170.6
		2	2.07	.23	12	57	....	9,370	10,290,000	.0013	.0089	.0107	....	....	....	2.810	....	....	....
		3	1.96	.24	12	40	.0740	6,380	8,060,000	.0011	.0090	.0113	.0029	.0246	.0310	....	2.733	....	170.3
	Average...	....	....	....	....	....	....	7,050	9,200,000	.0011	.0089	.0110	.0029	.0245	.0305	2.808	2,736	.0256	170.5
9	Misc. 149.....	1	1.99	.17	7	48	.0317	8,760	13,150,000	.0010	.0073	.0088	.0029	.0203	.0244	2.849	2,764	....	172.2
		2	2.00	.14	7	47	.0358	12,590	19,530,000	.0010	.0081	.0091	.0029	.0227	.0256	2.845	2.806	....	174.8
		3	2.00	.22	4	120	....	7,440	....	.0009	.0082	.0091	.0026	.0229	.0255	....	2.789	....	173.8
	Average...	....	....	....	....	....	....	9,600	16,340,000	.0010	.0079	.0090	.0028	.0220	.0252	2.847	2.786	.0214	173.6
11	Misc. 150.....	1	1.97	.53	9	139	.0181	3,390	4,720,000	.0183	.0410	.0410	.0467	.1045	.1045	2.828	2,552	....	159.0
		2	1.94	.51	9	155	.0181	4,150	6,090,000	.0185	.0402	.0404	.0471	.1023	.1029	2.830	2.546	....	158.6
		3	1.93	.52	9	140	.0206	3,620	4,500,000	.0084	.0365	.0365	.0216	.0941	.0941	....	2.576	....	160.5
	Average...	....	....	....	....	....	....	3,720	5,100,000	.0151	.0392	.0393	.0385	.1003	.1005	2.829	2.558	.0958	159.4
8	Misc. 148.....	1	1.94	.15	7	20	.0265	4,810	9,820,000	.0016	.0094	.0101	.0045	.0263	.0283	2.863	2.801	....	174.5
		2	2.04	.17	7	36	.0330	6,410	9,410,000	.0010	.0081	.0096	.0028	.0227	.0272	2.866	2.822	....	175.8
		3	2.02	.17	7	32	.0250	5,760	15,810,000	.0010	.0089	.0098	.0027	.0252	.0279	....	2.838	....	176.8
	Average...	....	....	....	....	....	....	5,660	11,680,000	.0012	.0088	.0098	.0033	.0247	.0278	2.865	2.820	.0157	175.7

[a] Apparent specific gravity ÷ true specific gravity.

10	Misc. 148.....	1	1.99	.12	7	9.75	.0430	3,570	5,730,000	.0088	.0251	....	....	....	....	2.854	....	....	....
		2	1.93	.13	7	8	.0378	2,570	4,250,000	.0072	.0257	.0257	.0194	.0689	.0689	2.857	2.682	....	167.1
		3	1.97	.14	7	18	.0440	4,890	6,340,000	.0067	.0251	.0253	.0180	.0672	.0677	....	2.676	....	166.7
	Average...	....	....	....	....	....	....	3,680	5,440,000	.0076	.0253	.0255	.0187	.0681	.0683	2.856	2.679	.0620	166.9
13	Misc. 148.....	1	2.03	.15	6	20	.0440	3,940	3,550,000	.0046	.0228	.0229	.0124	.0613	.0617	2.862	2.691	....	167.6
		2	2.00	.16	6	20	.0300	3,520	4,420,000	.0062	.0243	.0243	.0167	.0652	.0652	2.860	2.683	....	167.1
		3	1.93	.18	6	24	.0180	3,450	6,480,000	.0061	.0241	.0244	.0163	.0640	.0648	....	2.658	....	165.6
	Average...	....	....	....	....	....	....	3,640	4,820,000	.0056	.0237	.0239	.0151	.0635	.0639	2.861	2.677	.0643	166.8

NOTE.—Specific gravities corrected at 70° F.

COMPARATIVE CHARACTERISTICS OF SLATES.

The accompanying table shows the principal mineralogic, chemical, and physical characteristics of 56 kinds of slate described by the writer in this bulletin, so far as these characteristics manifestly bear on their economic value. These slates are from Arkansas, California, Colorado, Georgia, Maine, Maryland, Nevada, New Jersey, New York, Pennsylvania, Tennessee, Vermont, Virginia, and West Virginia. For full particulars and for scientific details the descriptions should be consulted, by reference to the pages given in the third column. The columns headed "Strength" and "Toughness" refer to the tests by Merriman, whose methods of experimentation are described on page 175. "Microscopic texture" refers primarily to the matrix or body of the slate. By "crystalline" is meant that the matrix consists of interlacing and overlapping scales and fibers of muscovite and is therefore a mica slate or technically a phyllite slate, although it may inclose unaltered particles of sedimentary origin. Such a slate should have, other things being equal, greater elasticity (toughness) and strength than one in which there is no such texture or in which it is only incipient. The fineness or coarseness of this crystalline texture probably has a bearing on the strength and toughness of the slate, but physical data are not sufficient to show this. The coarse-textured Peach Bottom slate, which really approaches a mica schist, is the strongest of the twelve kinds of American slates tested, but it is less flexible than all the other kinds tested. In the grade of fissility 1 signifies a perfect slaty cleavage, 4 a very imperfect one. The column of "Chief minerals" includes only the four or five principal constituents which were seen under the microscope or whose presence has been otherwise determined, and these are given in the descending order of their probable abundance. In the column headed "Class" the technical economic designation of each slate is given with reference to the classification on page 10. To these comparative data should be added the results of a few tests not easily tabulated.

Merriman's later corrosion tests show the following percentages of loss in weight after immersion in acid solution for 360 hours: Pennsylvania slates (not including Peach Bottom slate), 1.68 to 2.76; Peach Bottom slate, 1.11 to 1.29; red slate of New York and Vermont, 0.25. During these tests the Pennsylvania slates became a grayish white, some of the Peach Bottom samples changed but slightly, others were almost unaffected; the red slates likewise remained almost unaffected.[1]

E. H. S. Bailey's tests of porosity give these indices of porosity: "Hard vein" Pennsylvania, Chapman, 0.11–0.14; Daniels quarry, 0.14; Belfast quarry, 0.25; red of New York and Vermont, 0.21.[2]

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[1] Am. Soc. Civil Eng. Trans., vol. 32, p. 538, 1894.

[2] Idem, p. 542.

hematite,	Mica slat
arbonate,	.....do...
, chlorite,	.....do...
e, chlorite.	Mica slat
te, hema-	.....do...
carbonate.	Mica slat
hematite..	.....do...
e, pyrite..	Mica slat
arbonate,	Mica slat
arbonate,	.....do...
, carbon-	.....do...
, biotite,	.....do...
, kaolin?	.....do....
specular,	.....do....
arbonate,	Mica slat on expo
arbonate,	Mica slat
kaolin....	Mica slate
z, kaolin,	Clay slate

tion, in inches, on su

J. F. Williams's tests of the compression of columns of slate 10 inches long by an inch in section, with the cleavage vertical, show that the purplish of the "unfading green" series of Vermont stands 20,000 pounds; the "unfading green," 16,020 pounds, and the red of New York and Vermont 17,730 pounds.[1]

The following results of various tests of slate from Monson, Maine, were made at the United States Arsenal at Watertown, Mass.:[2]

	Pounds.
Maximum fiber stress per square inch	7,671
Shearing test per square inch	2,192
Ultimate compressive strength per square inch	19,510

Coefficient of expansion, 0.000005.

In accordance with the scheme of classification of slates given on pages 10, 11 many of the slates whose characteristics are given in the preceding table are here arranged systematically.

- A. Clay slates (fading) Martinsburg, W. Va.
- B. Mica slates
  - (fading)
    - (a) Carbonaceous or graphitic (blackish). Lehigh, Northampton, and Carbon counties, Pa.; Sussex County, N. J.; Benson, Vt.; Rockmart, Ga.
    - (b) Chloritic (greenish). "Sea-green," Vermont; green, Bartow County, Ga.
    - (c) Hematitic and chloritic (purplish). Purplish of Pawlet and Poultney, Vt.
  - (unfading.)
    - (a) Graphitic (blackish).
      - Peach Bottom, Pa. and Md.
      - Arvonia and Penlan, Va.
      - Northfield, Vt.
      - Brownville, Monson, Me.
      - North Blanchard, Me.
      - Merced County, Cal.
      - Humboldt County, Nev.
    - (b) Hematitic (reddish). Granville, Hampton, N. Y.; Polk County, Ark.
    - (c) Chloritic (greenish). "Unfading green," Vermont; "bright green," Granville, N. Y.; green, Tellico, Tenn.
    - (d) Hematitic and chloritic (purplish). Purplish of Fair Haven, Vt.; Thurston, Md.; and Tellico, Tenn.
    - (e) Hematitic (specular) and graphitic (bluish black). "Blue-black" of Esmont, Va.

SLATE MACHINERY.

A description of all the various machines used in quarrying and finishing slate is not within the scope of this publication, but attention will be briefly called here to the growing substitution of cutting machinery for powder in quarrying slate and to the new devices for finishing it.

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[1] Van Nostrand's Eng. Mag., vol. 31, p. 132, 1884.

[2] War Dept. reports, republished in Twentieth Ann. Rept. U. S. Geol. Survey, pt. 6 (contd.), p. 395, 1899.

It will be noticed from the quarry descriptions that where the cleavage is nearly horizontal, as in some of the Pennsylvania quarries, or where it is nearly vertical, as in the Maine quarries, machines for vertical or horizontal cutting, constructed on the same principle as those used in the marble quarries, are being used, and in connection with them air compressors are also being introduced. The reduction of waste by these processes is obvious. The attempt, referred to on page 159, to do all the transverse cutting of large blocks by circular saws is of interest. Among the minor improvements is the automatic transportation of waste from the cutting sheds to dumps at a distance (p. 159) and the use of carborundum wheels in finishing slate moldings, etc.

The most important recent addition to the mechanical devices in the ndustry is the slate-splitting machine invented by Vincent F. Lake, which, in January, 1913, was on exhibition at the plant of the Genuine Washington Slate Co., at Berlinsville, Pa. The underlying principle of this machine is the substitution for the sudden jar given to the slate by the hand-splitter's hammer and chisel of a great number of blows, each of which moves the chisel a small fraction of an inch only, while the operator presses the vibrating chisel into the cleft slate as it parts. These vibrations, numbering as many as 16,000 a minute, are imparted to the chisel by means of a broad-edged iron cylinder 6 inches in diameter into which are sunk 24 small steel cylinders projecting but slightly above its edge. The rapid rotation of the main cylinder with its minor ones coming into contact with a single cylinder carried in a piston to which the chisel is attached imparts the vibratory motion. The slate block, preferably with one or more sawn edges, is placed with its long edge on an iron table and with its short edge facing the operator. (See Pl. VI, *B*.) The chisel, a very thin blade of vanadium steel, 9 inches or more in width but made flexible by splits at intervals and with its edge vertical, is set loosely in the piston socket. The edge of the slate is held between gages mechanically adjusted and operated by a treadle so that the exact center of the slab is brought before the chisel. The operator controls the intensity of the hammer blow by means of a trigger and pushes the chisel horizontally through the block.

This machine can be operated with little skill and makes commercial slate from blocks which now find their way to the dumps. It also makes slate of unusual thinness. Mr. Lake has also perfected a punch for making beveled holes of any shape in slate with a view of utilizing slates of various thicknesses as a foundation for plaster and stucco work. The perforated slates are nailed to the studding or furring, and the plaster, applied directly to the slate, passes through the perforations and clinches itself on the back.

The slate-splitting machine thus seems likely not only to reduce the cost of splitting but also the percentage of waste, and to make new demands for slate.

USES OF SLATE.

As will be seen by consulting the descriptions in this bulletin and the table opposite page 188, the slates of the United States have a very wide range of color, texture, and composition and therefore of adaptation. While nearly all of them possess one or two excellent features, few possess many such features and none possess them all. Several are so conspicuous for their well-nigh perfect adaptation to certain uses that the demand for them is likely to increase with the growth of the country. Such are the blackboard slates of the "soft-vein" region of Pennsylvania, the red roofing slates of New York, which increase in brightness of color on exposure, and the fadeless bright-green ones associated with them; the black unfading slates of the Peach Bottom district of Maryland and Pennsylvania, of Arvonia, Penlan, and Esmont, in Virginia, and of Monson and Brownville, in Maine; the almost unfading green slates of Vermont; and the mill-stock slates of Vermont, Maine, and Pennsylvania.

On account of their cheapness, which is due to their perfect cleavage, the "sea-green" slates of Vermont and the black slates of Lehigh and Northampton counties, Pa., will always be in demand in spite of their content of ferrous carbonate. Some architects are reported as preferring such fading slates for esthetic reasons.

The selection of a slate should manifestly be governed mainly by its adaptation to the purpose in view as well as by considerations of cost and transportation.

An increasing quantity of mill-stock slate is used for electric purposes, but this use requires a minimum content of magnetite. It would be well if the more durable slates were more widely used for inexpensive tablets and gravestones instead of marble. Facts showing the relative durability of inscriptions on slate and marble exposed to the weather will be found in Bulletin 521 of the United States Geological Survey.[1]

There are also many structures where thick slate slabs with their great transverse strength could be used to advantage instead of concrete beams. Finally should be mentioned the proposed substitution of slate veneers for laths, described on page 190.

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[1] Dale, T. N., The commercial marbles of western Vermont, pp. 37-39, 1912.

SLATE WASTE.

The percentage of waste is generally high in slate quarrying. Watrin,[1] referring to the Ardennes region, gives the total waste at 70 to 75 per cent in weight, of which 20 to 25 per cent occurs in the quarry and 50 per cent in splitting. Merrill estimates the waste in the Peach Bottom region as 88 per cent. In the Maine quarries it is also large, owing to the interbedding of the slate with quartzite. Among the important practical problems in the slate industry is that of the reduction of this large percentage of waste and the utilization of the unavoidable remainder. The substitution, wherever practicable, of mechanical cutting for blasting is probably the most available method of effecting this reduction. Much ingenuity has been expended in devising methods of utilizing slate waste. The slate-splitting machine described above aims to make a contribution to this end. The growing use in roofing of "graduated slates," which near the ridge are one-fourth inch thick but at the cornice 1½ inches thick, consumes slates with imperfect cleavage. The Inlaid Slate Co. of Bangor, Pa., is utilizing slate 3 inches square embedded in a mixture of asphalt having a high melting point with a backing of roofing felt for covering flat roofs.[2] A demand for waste slate has also arisen from the use of powdered slate for filling in oilcloth, etc., and of granulated slate for roofing. The particles, averaging about 0.1 inch in diameter, are pressed into a tarred paper (Staco Mills, Whitehall, N. Y.). The bright-red slate waste of Granville, N. Y., is being used by the Algonkian Red Slate Co., of Truthville, N. Y., for roofing and bridge paint by being combined with several superior oils and a small quantity of white lead. An article by one of the editors of the Slate Trades Gazette (England) describes the use being made of powdered slate in Norway.[3]

> At the present time in Norway waste slate is being ground into a fine powder and mixed with casein, * * * the nitrogenous constituent (curd) of milk. The casein may be either solid or liquid, the proportion varying according to the nature of the slate. Hard and soft slates obviously require different treatment. The casein may be pure or mixed with other substances—lime, soda, resins, or acids—according to the character of the product required. If the final resultant is required to be of any particular tint, coloring matter is introduced at this stage. The composition thus obtained is plastic and is placed hot or cold in molds and subjected to pressure. The material is then exposed to the drying action of the air. The final product has properties identical with those of slate except that the casein, if anything, renders it harder and tougher. The casein can be made insoluble by the application of formaldehyde. The compressed slate is then ready to undergo sawing, planing, polishing, etc. * * *
>
> All manner of fancy designs may be imprinted on the plastic slate, which may be manufactured into blocks of uniform size or in large sheets, and the thickness may, of course, be regulated by the pressure. This material could be used as a covering for

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[1] Watrin, N., Les ardoisières des Ardennes, 1898.

[2] U. S. Geol. Survey Mineral Resources for 1910, pt. 2, p. 632, 1911.

[3] Idem for 1909, pt. 2, p. 560, 1910.

walls, either internally or externally, in place of the ordinary wall paper or plaster, or to enhance the picturesqueness of the slate roof. Embossed mantelpieces could also be made and other uses would in course of time reveal themselves.

Chemists have also considered the feasibility of utilizing slate waste for the manufacture of aluminum, and when combined with lime for the manufacture of cement, but as clay would answer both purposes equally well and is abundant these schemes have been given up.

STATISTICS OF PRODUCTION, IMPORTS, AND EXPORTS.

By A. T. Coons.

PRODUCTION.

Although slate has been known and quarried in this country more or less since 1750 in Massachusetts, Maryland, and Pennsylvania and since about 1850 in New York, Vermont, Georgia, California, Virginia, and other States, no statistics of production for the entire United States are obtainable for any year preceding 1879.

In the tables here presented the production for the years 1879, 1881, 1882, and 1883 is largely estimated. The statistics for 1880 are taken from the Tenth Census and are very accurate. The figures from 1884 to 1888 are fairly reliable; those for 1889 are the figures of the Eleventh Census; and from 1890 to the present time the data as to production have been obtained directly from the slate quarries and are as accurate as can be procured. There is no record of production in New York from 1884 to 1890, but as the operations in this State are closely allied to those of Vermont the output is doubtless included in that of Vermont.

The statistics of the production of slate as here given represent the output of slate as reported by the slate quarrymen and include the quantity and value of roofing slate and of mill stock sold by them and the value of slate sold for other purposes. The values given for both mill stock and roofing slate represent prices f. o. b. at the point of shipment, the mill stock being classed as rough or manufactured, according to the condition in which it is sold by the quarrymen, whether as rough blocks to slate mills or in a finished or partly finished state from mills at the quarries.

The tables give the output of slate in the United States from 1879 to 1913 by States, showing as nearly as possible the number of squares of roofing slate produced, their value, and the quantity and value of slate used for other purposes so far as figures are obtainable.

Production of slate in the United States, by States and uses, from 1879 to 1913.

State.	1879		1880		1881		1882	
	Roofing slate.		Roofing slate.		Roofing slate.		Roofing slate.	
	Squares.	Value.	Squares.	Value.	Squares.	Value.	Squares.	Value.
Georgia	....	....	1,000	$4,500	500	$2,250	200	$900
Maine	14,000	$42,000	26,200	84,800	25,200	77,500	26,000	78,000
Maryland	8,000	36,000	12,280	56,700	12,000	54,000	15,000	67,500
Massachusetts	....	....	1,550	7,000	1,000	4,500	500	2,000
New Jersey	....	....	4,683	15,000	3,000	10,500	4,000	12,000
New York	9,000	45,000	19,850	95,500	19,000	95,000	21,000	105,000
Pennsylvania	245,500	826,093	271,313	862,877	272,000	877,978	292,000	1,002,000
Vermont	83,300	249,900	108,891	352,608	109,370	368,110	127,300	435,100
Virginia	8,057	32,228	11,500	51,000	12,000	54,000	15,000	51,000
	367,857	1,231,221	457,267	1,529,985	454,070	1,543,838	501,000	1,753,500

State.	1883		1884			
	Roofing slate.		Roofing slate.		Other purposes than roofing slate.	Total value.
	Squares.	Value.	Squares.	Value.		
Maine	30,000	$120,000	41,000	$215,000	....	$215,000
Maryland	15,000	67,500	[a] 10,000	45,000	....	45,000
Michigan	5,000	18,250	7,000	35,300	....	35,300
New Jersey	1,000	4,000	....	....	....	....
New York	10,200	51,000	....	....	....	....
Pennsylvania	325,000	1,147,500	329,004	1,162,560	....	1,162,560
Vermont	110,000	440,000	85,000	340,500	....	340,500
Virginia	10,000	50,000	9,000	45,505	....	45,505
	506,200	1,898,250	481,004	1,843,865	$8,000	1,851,865

State.	1885				1886		1887	
	Roofing slate.		Other purposes than roofing slate.	Total value.	Roofing slate.		Roofing slate.	
	Squares.	Value.			Squares.	Value.	Squares.	Value.
Maine	34,000	$102,000	....	$102,000	36,000	$118,000	37,000	$81,000
Maryland	[a] 14,500	65,250	....	65,250	[a] 12,000	54,000	[a] 20,000	90,000
Michigan	10,000	40,000	....	40,000	12,000	46,000	7,000	25,000
Pennsylvania	331,160	993,080	....	993,080	348,805	979,415	370,439	1,111,317
Vermont	130,000	380,000	....	380,000	111,385	353,155	120,000	356,000
Virginia	17,300	58,137	....	58,137	16,600	59,800	19,000	57,000
	536,960	1,638,467	$10,000	1,648,467	536,790	1,610,370	573,439	1,720,317

[a] Includes Pennsylvania Peach Bottom.

Production of slate in the United States, by States and uses, from 1879 to 1913—Con.

State.	1888		1889			
	Roofing slate.		Roofing slate.		Other purposes than roofing slate.	Total value.
	Squares.	Value.	Squares.	Value.		
Arkansas	....	....	....	....	....	(a)
California	....	....	3,104	$18,089	....	$18,089
Georgia	....	....	3,050	14,850	$480	15,330
Maine	37,000	$111,000	41,000	201,500	18,000	219,500
Maryland	[b] 19,000	85,500	23,099	105,745	4,263	110,008
Michigan	7,000	24,000	....	....	....	(a)
New Jersey	6,000	22,000	2,700	9,675	1,250	10,925
New York	....	....	16,767	81,726	44,877	126,603
Pennsylvania	416,000	1,270,400	476,038	1,641,003	370,723	2,011,726
Utah	....	....	....	....	....	(a)
Vermont	160,000	480,000	236,350	596,997	245,016	842,013
Virginia	17,400	60,540	30,457	113,079	....	113,079
Other States	....	....	3,060	15,240	....	15,240
	662,400	2,053,440	835,625	2,707,904	684,609	3,482,513

State.	1891				1892			
	Roofing slate.		Other purposes than roofing slate.	Total value.	Roofing slate.		Other purposes than roofing slate.	Total value.
	Squares.	Value.			Squares.	Value.		
Arkansas	120	$480	....	$480	....	....	....	....
California	4,000	24,000	....	24,000	3,500	$21,000	....	$21,000
Georgia	3,000	13,500	....	13,500	2,500	10,625	....	10,625
Maine	50,000	250,000	....	250,000	50,000	250,000	....	250,000
Maryland	25,166	123,425	$2,000	125,425	24,000	114,000	$2,500	116,500
New Jersey	2,500	10,000	....	10,000	3,000	12,000	....	12,000
New York	17,000	136,000	40,000	176,000	20,000	160,000	50,000	210,000
Pennsylvania	507,824	1,741,836	401,069	2,142,905	550,000	1,925,000	408,000	2,333,000
Vermont	247,643	698,350	257,267	955,617	260,000	754,000	260,000	1,014,000
Virginia	36,059	127,819	....	127,819	40,000	150,000	....	150,000
	893,312	3,125,410	700,336	3,825,746	953,000	3,396,625	720,500	4,117,125

State.	1893				1894			
	Roofing slate.		Other purposes than roofing slate.	Total value.	Roofing slate.		Other purposes than roofing slate.	Total value.
	Squares.	Value.			Squares.	Value.		
California	....	....	....	....	900	$5,850	....	$5,850
Georgia	2,500	$11,250	....	$11,250	5,000	22,500	....	22,500
Maine	18,184	124,200	$15,000	139,200	24,690	123,937	$22,901	146,838
Maryland	7,422	37,884	....	37,884	39,460	150,568	2,500	153,068
New Jersey	900	3,653	....	3,653	375	1,050	....	1,050
New York	69,640	204,776	206	204,982	7,955	42,092	2,450	44,542
Pennsylvania	364,051	1,314,451	157,824	1,472,275	411,550	1,380,430	239,728	1,620,158
Utah	75	450	400	850	....	....	....	....
Vermont	132,061	407,538	128,194	535,732	214,337	455,860	202,307	658,167
Virginia	27,106	104,847	12,500	117,347	33,955	118,851	19,300	138,151
	621,939	2,209,049	314,124	2,523,173	738,222	2,301,138	489,186	2,790,324

[a] Included in other States.

[b] Includes Pennsylvania Peach Bottom.

Production of slate in the United States, by States and uses, from 1879 to 1913—Con.

State.	1895				1896			
	Roofing slate.		Other purposes than roofing slate.	Total value.	Roofing slate.		Other purposes than roofing slate.	Total value.
	Squares.	Value.			Squares.	Value.		
California	1,500	$10,500	....	$10,500	....	....	....	....
Georgia	2,500	10,675	....	10,675	4,597	$20,388	....	$20,388
Maine	23,774	118,791	$21,363	140,154	23,078	99,831	$24,255	124,086
Maryland	13,188	59,157	1,200	60,357	15,557	70,194	1,948	72,142
Massachusetts	....	....	....	....	....	....	1,200	1,200
New Jersey	200	700	....	700	200	700	....	700
New York	13,624	90,150	1,725	91,875	16,002	78,612	3,880	82,492
Pennsylvania	426,687	1,437,697	210,054	1,647,751	431,324	1,391,539	334,779	1,726,318
Tennessee	....	....	....	....	160	640	780	1,420
Vermont	221,359	531,482	93,849	625,331	155,523	509,681	99,915	609,596
Virginia	27,095	92,357	19,000	111,357	26,863	92,163	15,700	107,863
	729,927	2,351,509	347,191	2,698,700	673,304	2,263,748	482,457	2,746,205

State.	1897				1898			
	Roofing slate.		Other purposes than roofing slate.	Total value.	Roofing slate.		Other purposes than roofing slate.	Total value.
	Squares.	Value.			Squares.	Value.		
California	1,000	$7,000	....	$7,000	400	$2,700	....	$2,700
Georgia	....	....	....	....	3,450	13,125	....	13,125
Maine	38,367	161,262	$39,855	201,117	29,834	131,752	$67,485	199,237
Maryland	11,592	53,049	890	53,939	18,332	80,786	1,454	82,240
Massachusetts	....	....	....	....	....	....	958	958
Minnesota	400	1,000	500	1,500	100	400	....	400
New Jersey	250	775	....	775	200	800	....	800
New York	9,197	52,799	1,000	53,799	7,160	46,744	1,950	48,694
Pennsylvania	657,692	2,034,958	330,341	2,365,299	571,256	2,097,735	394,021	2,491,756
Vermont	244,575	656,114	39,701	695,815	241,762	612,902	119,782	732,684
Virginia	38,375	130,495	14,875	145,370	43,745	142,446	8,500	150,946
	1,001,448	3,097,452	427,162	3,524,614	916,239	3,129,390	594,150	3,723,540

State.	1899				1900			
	Roofing slate.		Other purposes than roofing slate.	Total value.	Roofing slate.		Other purposes than roofing slate.	Total value.
	Squares.	Value.			Squares.	Value.		
California	928	$6,642	....	$6,642	3,500	$26,500	....	$26,500
Georgia	2,000	7,500	....	7,500	2,500	9,375	....	9,375
Maine	24,676	121,640	$60,126	181,766	21,771	103,949	$73,393	177,342
Maryland	20,196	90,897	2,698	93,595	27,158	126,271	2,402	128,673
Massachusetts	....	....	800	800	....	....	....	....
Minnesota	....	....	....	....	....	....	700	700
New Jersey	400	1,600	....	1,600	3,600	13,600	....	13,600
New York	10,912	69,525	7,150	76,675	7,713	58,360	4,395	62,755
Pennsylvania	711,138	2,202,742	334,280	2,537,022	788,571	2,277,192	436,406	2,713,598
Tennessee	50	250	....	250	50	250	....	250
Utah	200	1,100	....	1,100	....	....	....	....
Vermont	277,463	777,971	94,702	872,673	282,820	795,474	121,988	917,462
Virginia	52,550	174,950	8,160	183,110	56,365	185,211	5,000	190,211
	1,100,513	3,454,817	507,916	3,962,733	1,194,048	3,596,182	644,284	4,240,466

Production of slate in the United States, by States and uses, from 1879 to 1913—Con.

State.	1901				1902			
	Roofing slate.		Other purposes than roofing slate.	Total value.	Roofing slate.		Other purposes than roofing slate.	Total value.
	Squares.	Value.			Squares.	Value.		
Arkansas					500	$4,000		$4,000
California	2,500	$18,608		$18,608	4,500	31,500		31,500
Georgia	800	3,000		3,000	1,000	4,000		4,000
Maine	20,791	111,295	$91,030	202,325	26,468	143,832	$62,726	206,558
Maryland	20,153	104,781	1,017	105,798	22,569	117,155	929	118,084
Minnesota			1,400	1,400				
New Jersey	7,500	30,000		30,000	8,000	32,000		32,000
New York	15,786	91,805	9,155	100,960	21,165	116,628	10,090	126,718
Pennsylvania	853,028	2,591,625	392,639	2,984,264	908,206	3,001,545	545,777	3,547,322
Vermont	330,191	984,317	177,874	1,162,191	400,029	1,338,817	126,101	1,464,918
Virginia	53,630	178,979		178,979	42,731	160,951		160,951
	1,304,379	4,114,410	673,115	4,787,525	1,435,168	4,950,428	745,623	5,696,051

State.	1903				1904			
	Roofing slate.		Other purposes than roofing slate.	Total value.	Roofing slate.		Other purposes than roofing slate.	Total value.
	Squares.	Value.			Squares.	Value.		
Arkansas	118	$709	$4,000	$4,709	1,750	$10,300	$4,000	$14,300
California	10,000	70,000		70,000	5,600	39,200		39,200
Georgia					1,000	4,500		4,500
Maine	27,377	157,911	73,319	231,230	20,789	120,838	60,330	181,168
Maryland	24,475	135,424	2,207	137,631	22,628	131,245	2,727	133,972
New Jersey	7,647	33,403		33,403				
New York	15,690	89,548	22,450	111,998	10,022	64,102	7,441	71,543
Pennsylvania	871,875	3,378,804	581,102	3,959,906	778,825	2,922,259	710,987	3,633,246
Tennessee					115	607		607
Utah					50	300		300
Vermont	391,366	1,363,923	228,729	1,592,652	361,126	1,245,730	162,421	1,408,151
Virginia	29,646	115,356		115,356	31,852	130,208		130,208
	1,378,194	5,345,078	911,807	6,256,885	1,233,757	4,669,289	947,906	5,617,195

State.	1905				1906			
	Roofing slate.		Value of mill stock.	Total value.	Roofing slate.		Value of mill stock.	Total value.
	Squares.	Value.			Squares.	Value.		
Arkansas	50	$350	$9,650	$10,000			$5,000	$5,000
California	5,000	40,000		40,000	10,000	$80,000		80,000
Georgia	1,500	7,500		7,500	1,000	5,000		5,000
Maine	19,865	106,271	117,983	224,254	18,498	100,916	137,765	238,681
Maryland	25,845	149,315	1,900	151,215	25,288	129,965	1,004	130,969
New Jersey	1,340	5,360		5,360				
New York	10,354	65,051	1,595	66,646	10,788	60,000	12,360	72,360
Pennsylvania	802,170	2,879,671	612,234	3,491,905	755,966	2,710,249	811,900	3,522,149
Vermont	339,001	1,174,246	178,295	1,352,541	354,134	1,189,799	251,531	1,441,330
Virginia	36,102	146,786		146,786	39,068	172,857		172,857
	1,241,227	4,574,550	921,657	5,496,207	1,214,742	4,448,786	1,219,560	5,668,346

Production of slate in the United States, by States and uses, from 1879 to 1913—Con.

State.	1907					
	Roofing slate.		Mill stock.		Other.	Total value.
	Squares.	Value.	Quantity.	Value.		
			Square feet.			
Arkansas					[a] $8,500	$8,500
California	7,000	$60,000				60,000
Maine	16,879	91,583	404,829	$145,023		236,606
Maryland	21,815	113,665			2,395	116,060
New Jersey	2,000	8,000				8,000
New York	11,908	81,535	13,000	1,950		83,485
Pennsylvania	793,466	2,987,740	4,597,884	620,753	[b] 247,147	3,855,640
Vermont	385,314	1,301,576	963,911	175,683		1,477,259
Virginia	39,172	173,670				173,670
	1,277,554	4,817,769	5,979,624	943,409	258,042	6,019,220

State.	1908						
	Number of operators.	Roofing slate.		Mill stock.		Other.	Total value.
		Squares.	Value.	Quantity.	Value.		
				Square feet.			
Arkansas	1					$2,500	$2,500
California	1	7,000	$60,000				60,000
Maine	5	20,151	115,682	285,299	$98,025		213,707
Maryland	6	18,521	101,204			982	102,186
New Jersey	2	18,485	130,439	1,500	180		130,619
New York	11						
Pennsylvania	102	825,078	3,070,906	3,565,083	498,188	[c] 333,864	3,902,958
Vermont	51	402,258	1,513,580	941,930	196,911		1,710,491
Virginia	7	41,678	194,356				194,356
	186	1,333,171	5,186,167	4,793,812	793,304	337,346	6,316,817

State.	1909						
	Number of operators.	Roofing slate.		Mill stock.		Other.	Total value.
		Squares.	Value.	Quantity.	Value.		
				Square feet.			
California	1						(d)
Georgia	1						(d)
Maine	6	18,021	$101,865	372,229	$126,017		$227,882
Maryland	6	22,563	128,227			$1,311	129,538
New Jersey	2						(d)
New York	8	18,098	106,175	6,043	1,261		107,436
Pennsylvania	98	626,228	2,281,779	3,380,119	441,464	[e] 169,115	2,892,358
Vermont	51	397,441	1,533,936	1,315,503	307,347	306	1,841,589
Virginia	7	40,880	180,775				180,775
Other States [f]		10,479	61,840				61,840
	180	1,133,713	4,394,597	5,112,894	876,089	170,732	5,441,418

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[a] Used chiefly for electric supplies.

[b] Composed of 5,711,105 school slates valued at $48,152 and 1,531,330 square feet of blackboard material, valued at $198,995.

[c] Composed of 5,036,147 school slates, valued at $42,364, and 2,388,886 square feet of blackboard material, valued at $291,500.

[d] Included in "Other States."

[e] Composed of 3,650,831 school slates, valued at $32,319; 1,095,540 square feet of blackboard material, valued at $130,195; and $6,601 for slate used for structural and other purposes.

[f] Includes California, Georgia, and New Jersey.

Production of slate in the United States, by States and uses, from 1879 to 1913—Con.

State.	1910						
	Number of operators.	Roofing slate.		Mill stock.		Other.	Total value.
		Squares.	Value.	Quantity.	Value.		
				Square feet.			
California	1						(a)
Georgia	2						(a)
Maine	6	16,708	$99,023	385,307	$149,982		$249,005
Maryland	4	14,529	77,791			$782	78,573
New Jersey	2						(a)
New York	6	17,618	84,089	2,933	733		84,822
Pennsylvania	104	777,190	2,809,593	3,476,526	539,572	[b] 391,641	3,740,806
Tennessee	1						(a)
Vermont	48	395,640	1,585,324	1,316,732	308,811	524	1,894,659
Virginia	7	31,787	148,721				148,721
Other States [c]		7,149	40,123			50	40,173
	181	1,260.621	4,844,664	5,181,498	999,098	392,997	6,236,759

State.	1911						
	Number of operators.	Roofing slate.		Mill stock.		Other.	Total value.
		Squares.	Value.	Quantity.	Value.		
				Square feet.			
Arkansas	2						(a)
Georgia	1						(a)
Maine	5	14,879	$98,074	394,531	$165,442		$263,516
Maryland	4	14,816	74,692			$1,343	76,035
New Jersey	2						(a)
New York	9	21,452	120,359				120,359
Pennsylvania	97	699,344	2,508,435	4,029,663	574,966	[d] 347,950	3,431,351
Vermont	49	328,760	1,335,244	1,320,383	287,197	2,500	1,624,941
Virginia	7	40,040	188,808				188,808
Other States [c]		5,386	22,959			50	23,009
	176	1,124,677	4,348,571	5,744,577	1,027,605	351,843	5,728,019

State.	1912						
	Number of operators.	Roofing slate.		Mill stock.		Other.	Total value.
		Squares.	Value.	Quantity.	Value.		
				Square feet.			
Arkansas	1						(a)
Maine	3	16,640	$96,079	428,689	$186,599		$282,678
Maryland	4	18,236	90,993			$1,191	92,184
New Jersey	2						(a)
New York	10	27,024	135,136			71	135,207
Pennsylvania	93	716,770	2,528,791	4,101,200	552,929	[e] 392,527	3,474,247
Vermont	54	373,638	1,576,294	1,234,384	273,582	99	1,849,975
Virginia	8	42,220	195,392				195,392
Other States [c]		2,760	13,500	1,000	110	25	13,635
	175	1,197,288	4,636,185	5,765,273	1,013,220	393,913	6,043,318

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[a] Included in "Other States."

[b] Composed of 5,610,518 school slates, valued at $47,075; 2,821,689 square feet of blackboard material, valued at $334,070; and $10,496 for slate used for structural and other purposes.

[c] Includes, in 1910, California, Georgia, New Jersey, and Tennessee; in 1911, Arkansas, Georgia, and New Jersey; in 1912, Arkansas and New Jersey.

[d] Composed of 4,308,292 school slates, valued at $35,157; 2,636,650 square feet of blackboard material, valued at $300,034; and $12,759 for slate used for structural and other purposes.

[e] Composed of 4,482,571 school slates, valued at $38,852; 2,898,742 square feet of blackboard material, valued at $352,109, and $1,566 for slate used for structural and other purposes.

Production of slate in the United States, by States and uses, from 1879 to 1913—Con.

State.	1913						
	Number of operators.	Roofing slate.		Mill stock.		Other.	Total value.
		Squares.	Value.	Quantity.	Value.		
Georgia	2	(a)	(a)				(a)
Maine	4	15,593	$89,933	513,745	$234,065		$323,998
Maryland	3	15,913	82,981			$1,012	83,993
New Jersey	2	(a)	(a)			(a)	(a)
New York	10	29,868	139,970	21,342	4,912		144,882
Pennsylvania	90	678,396	2,605,882	4,210,515	648,216	b 479,483	3,733,581
Vermont	53	332,642	1,351,175	1,566,409	346,645		1,697,820
Virginia	7	38,330	175,774			56	175,830
Other States c		3,202	15,347			25	15,372
Total	171	1,113,944	4,461,062	6,312,011	1,233,838	480,576	6,175,476

a Included in "Other States."
b Composed of 6,174,526 school slates, valued at $51,313; 3,504,162 square feet of blackboard material, valued at $426,703; and slate used for structural and other purposes, valued at $1,467.
c Includes Georgia and New Jersey.

The following table shows the number of squares and value of roofing slate, average value per square, and value of mill stock, by years, from 1879 to 1913, inclusive:

Values of roofing slate produced in the United States, 1879–1912.

Year.	Roofing slate.			Mill stock.			Other uses (value).	Total value.
	Squares.	Value.	Average price per square.	Quantity.	Value.	Average price (square foot).		
				Square feet.				
1879	367,857	a$1,231,221	$3.35					a$1,231,221
1880	457,267	a1,529,985	3.35					a1,529,985
1881	454,070	a1,543,838	3.40					a1,543,838
1882	501,000	a1,753,500	3.50					a1,753,500
1883	506,200	a1,898,250	3.75					a1,898,250
1884	481,004	1,843,865	3.83		$8,000			1,851,865
1885	536,960	1,638,467	3.05		10,000			1,648,467
1886	536,790	1,610,370	3.00					1,610,370
1887	573,439	1,720,317	3.00					1,720,317
1888	662,400	2,053,440	3.10					2,053,440
1889	835,625	2,797,904	3.35		684,609			3,482,513
1891	893,312	3,125,410	3.50		700,336			3,825,746
1892	953,000	3,396,625	3.56		720,500			4,117,125
1893	621,939	2,209,049	3.55		314,124			2,523,173
1894	738,222	2,301,138	3.12		489,186			2,790,324
1895	729,927	2,351,509	3.22		347,191			2,698,700
1896	673,304	2,263,748	3.36		482,457			2,746,205
1897	1,001,448	3,097,452	3.09		427,162			3,524,614
1898	916,239	3,129,390	3.42		594,150			3,723,540
1899	1,100,513	3,454,817	3.14		507,916			3,962,733
1900	1,194,048	3,596,182	3.01		644,284			4,240,466
1901	1,304,379	4,114,410	3.15		673,115			4,787,525
1902	1,435,168	4,950,428	3.45		745,623			5,696,051
1903	1,378,194	5,345,078	3.88		911,907			6,256,985
1904	1,233,757	4,669,290	3.78		947,906			5,617,196
1905	1,241,227	4,574,550	3.69		921,657			5,496,207
1906	1,214,742	4,448,786	3.66		1,219,560			5,668,346
1907	1,277,554	4,817,769	3.77	5,979,624	943,409	$0.157	b$258,042	6,019,220
1908	1,333,171	5,186,167	3.89	4,793,812	793,304	.165	b337,346	6,316,817
1909	1,133,713	4,394,597	3.87	5,112,894	876,089	.171	b170,732	5,441,418
1910	1,260,621	4,844,664	3.84	5,181,498	999,098	.192	b392,997	6,236,759
1911	1,124,677	4,348,571	3.87	5,744,577	1,027,605	.178	b351,843	5,728,019
1912	1,197,288	4,636,185	3.87	5,765,273	1,013,220	.166	b393,913	6,043,318
1913	1,113,944	4,461,062	4.00	6,312,011	1,233,838	.195	b480,576	6,175,476

a Estimated.
b 1907 includes 5,711,105 school slates, valued at $48,152, and 1,531,330 square feet of blackboard material, valued at $198,996; 1908 includes 5,036,147 school slates, valued at $42,364, and 2,388,886 square feet of blackboard material, valued at $291,500; 1909 includes 3,650,831 school slates, valued at $32,319, and 1,386,540 square feet of blackboard material, valued at $130,195; 1910 includes 5,610,518 school slates, valued at $47,075, and 2,821,689 square feet of blackboard material, valued at $334,070; 1911 includes 4,308,292 school slates, valued at $35,157, and 2,636,650 square feet of blackboard material, valued at $300,034; 1912 includes 4,482,571 school slates, valued at $38,852, and 2,898,742 square feet of blackboard material, valued at $352,109; 1913 includes 6,174,526 school slates, valued at $51,313, and 3,504,162 square feet of blackboard material, valued at $426,703.

As will be seen from the above tables, the values from 1879 to 1889 do not represent the entire value of slate quarried, as no record of slate used for mantles, school slates, pencils, tombstones, etc., was kept. In 1885 there was a large decrease in the average value per square—from $3.83 in 1884 to $3.05 in 1885. From 1885 to 1892 both the price and production increased in value, but owing to the financial troubles of 1893 the output decreased considerably, or from a total of $4,117,125 in 1892 to $2,523,173 in 1893. Since that time the value of the output has steadily increased, being aided largely since 1896 by export trade, until in 1903 the value of the output was $6,256,885, the greatest yet obtained. In 1903, however, while the beginning of the year showed active operations in the slate industry, the later part of the year showed a greatly decreased demand, owing to strikes in the building trades. Several of the chief producing States showed decreased output of roofing slates, with increased price.

In 1908 and 1910 the slate output was practically the same as in 1903, owing to the increased production of mill stock. The output of roofing slate was larger in 1908 than in any other year for which statistics have been collected.

The largest average price per square obtained has been $4, in 1913. The value of slate used in the manufacture of blackboards and school slates has been separated from other mill stock since 1906 and included under "Other uses." This slate is obtained entirely from Pennsylvania, and a separation of these figures into quantity and value is shown in the footnote to the above table and also in the table showing the output of Pennsylvania by counties.

Pennsylvania, producing over 57 per cent of the total value of the slate in the United States, is practically the only State where the industry is not confined to one district, and the following table is given showing the production of this State by counties and by uses for the years 1909–1913:

Production of slate in Pennsylvania, by counties and uses, 1909–1913.

County.	Number of operators.	Roofing slate.			Mill stock.								Other (value).	Total value.
					Manufactured.		Rough.		Blackboards.		School slates.			
		Squares.	Value.	Price per square.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.		
1909.														
Carbon	1	12,843	$77,129	$3.69	......	......	......	......	......	......	......	......	......	$77,129
York (Peach Bottom)	3			6.19										
Lehigh	37	185,249	670,443	3.62	147,313	$40,119	575,903	$47,208	289,132	$21,747	1,885,221	$15,170	$5,398	800,085
Northampton	57	428,136	1,534,207	3.58	2,272,592	324,684	393,311	29,453	806,408	108,448	1,765,610	17,149	1,203	2,015,144
	98	626,228	2,281,779	3.64	2,419,905	364,803	969,214	76,661	1,095,540	130,195	3,650,831	32,319	6,601	2,892,358
1910.														
Carbon	1	14,291	75,191	2.25	......	......	......	......	......	......	......	......	......	75,191
York (Peach Bottom)	4			5.60										
Lehigh	43	216,743	697,964	3.22	294,730	73,092	173,052	18,578	1,522,741	172,448	2,627,821	22,429	464	984,975
Northampton	56	546,156	2,036,438	3.73	2,741,663	435,369	267,081	12,533	1,298,948	161,622	2,982,697	24,646	10,032	2,680,640
	104	777,190	2,809,593	3.62	3,036,393	508,461	440,133	31,111	2,821,689	334,070	5,610,518	47,075	10,496	3,740,806
1911.														
Carbon	1	17,354	91,573	3.58	......	......	......	......	......	......	......	......	......	91,573
Lancaster	1			5.00										
York (Peach Bottom)	5			5.55										
Lehigh	34	160,150	566,101	3.53	506,461	60,710	194,941	19,078	1,040,593	107,967	1,832,293	14,971	5,063	773,890
Northampton	57	521,840	1,850,761	3.55	3,188,160	487,015	140,101	8,163	1,596,057	192,067	2,475,999	20,186	7,696	2,565,888
	98	699,344	2,508,435	3.59	3,694,621	547,725	335,042	27,241	2,636,650	300,034	4,308,292	35,157	12,759	3,431,351
1912.														
Lancaster	2	18,135	99,810	5.71	......	......	......	......	......	......	......	......	......	99,810
York (Peach Bottom)	3			5.50										
Lehigh	33	158,603	571,269	3.60	394,419	53,764	197,930	19,619	902,697	101,686	3,109,417	27,650	......	773,988
Northampton	55	540,032	1,857,712	3.44	3,269,099	466,970	239,752	12,576	1,996,045	250,423	1,373,154	11,202	1,566	2,600,449
	93	716,770	2,528,791	3.53	3,663,518	520,734	437,682	32,195	2,898,742	352,109	4,482,571	38,852	1,566	3,474,247
1913.														
Lancaster	2	9,965	57,059	6.00	......	......	......	......	......	......	......	......	......	57,059
York (Peach Bottom)	3			5.71										
Lehigh	31	143,145	513,027	3.58	353,948	63,632	191,902	21,193	1,395,847	147,119	4,126,144	34,329	17	779,317
Northampton	54	525,286	2,035,796	3.88	3,116,338	535,284	548,327	28,107	2,108,315	279,584	2,048,382	16,984	1,450	2,897,205
	90	678,396	2,605,882	3.84	3,470,286	508,916	740,229	49,300	3,504,162	426,703	6,174,526	51,313	1,467	3,733,581

IMPORTS.

The importation of slate into this country has never assumed very great proportions, and the largest quantity was of course imported before the slate quarries of the United States were fairly developed and in running order. The following tables, taken from the reports of the Bureau of Statistics, Department of Commerce and Labor, and Bureau of Foreign and Domestic Commerce, Department of Commerce, show the value of roofing slate and other slate, chiefly slate mantels, chimney pieces, etc. From 1867 to 1875 the total annual value amounted to more than $100,000, the value of the roofing slate averaging two-thirds of the whole. In 1875 there was a decided drop in the value of roofing slate imported, and since that time the imports of roofing slate have amounted to practically nothing. The tariff act of October, 1913, reduced the duty on imported slate by half. Formerly the duty on slates, slate chimney pieces, mantels, slabs for tables, roofing slates, and all other manufactures of slate was 20 per cent ad valorem; the present rate is 10 per cent ad valorem.

The following table shows the value of roofing and other slates imported and entered for consumption in the United States from 1867 to 1913, inclusive:

Value of roofing and other slate imported and entered for consumption in the United States, 1867 to 1913, inclusive.

Year.	Roofing slate.	Other.	Total.	Year.	Roofing slate.	Other.	Total.
1867	$85,204	$37,510	$122,714	1891	$1,148	$12,373	$13,521
1868	118,776	16,045	134,821	1892	1,615	4,952	6,567
1869	85,364	19,602	104,966	1893	1,878	6,671	8,549
1870	107,521	19,879	127,400	1894	2,198	6,342	8,540
1871	117,484	21,381	138,865	1895	4,418	1,212	5,630
1872	107,192	25,925	133,117	1896	224	6,191	6,415
1873	91,503	26,643	118,146	1897	72	4,997	5,069
1874	80,519	27,519	108,038	1898	58	4,866	4,924
1875	16,342	42,022	58,364	1899	0	4,025	4,025
1876	2,051	44,266	46,317	1900	0	6,998	6,998
1877	4	34,479	34,483	1901	3	6,467	6,470
1878	275	39,935	40,210	1902	0	4,817	4,817
1879	620	46,260	46,880	1903	2,221	7,182	9,403
1880	72	51,165	51,237	1904	45	9,391	9,436
1881	2	46,862	46,864	1905	913	8,941	9,854
1882	154	45,774	45,928	1906	228	9,243	9,471
1883	2,813	44,375	47,188	1907	208	5,196	5,404
1884	16,099	34,640	50,739	1908			7,227
1885	5,196	56,913	62,109	1909			7,872
1886	4,366	60,512	64,878	1910			4,127
1887	529	46,188	46,717	1911			8,367
1888	765	44,069	44,834	1912			14,768
1889	481	35,828	36,309	1913			5,479
1890	369	34,602	34,971				

EXPORTS.

Almost from the beginning of the slate-quarrying industry in the United States slate has contributed to the export trade of this country. In 1876, 1877, 1878, and 1880 a large quantity of slate was exported, the greatest part going to Great Britain and the Continent, a remarkable feature being that several cargoes were shipped directly to Welsh ports, the base of the slate supply for Great Britain. From that time until 1896 Great Britain did not take much of the product, which found an outlet in South America, the West Indies, and Australia. In fact, British Australasia has always been one of the largest foreign consumers of American slate. Until 1884 no general record of the export movement was obtainable, but as probably 90 per cent was shipped from the port of New York, the following table is given, showing the shipment of slate from that port from 1876 to 1888. The export of manufactured slate is also shown in this table, and is almost entirely the value of school slates.

Value of exports of roofing and other slate from the port of New York from 1876 to 1888, inclusive.

Year.	Roofing slate.	Other.	Total.	Year.	Roofing slate.	Other.	Total.
1876	$377,233	$87,500	$464,733	1883	$54,063	$40,674	$94,737
1877	646,272	68,437	714,709	1884	90,262	53,021	143,283
1878	308,852	88,215	397,067	1885	115,206	49,965	165,171
1879	166,220	74,251	240,471	1886	79,064	40,804	119,868
1880	220,292	76,709	297,001	1887	62,052	39,560	101,612
1881	138,904	62,109	201,013	1888	116,119	46,142	162,261
1882	153,318	68,150	221,468				

The following table, taken from the report of the Bureau of Foreign and Domestic Commerce, Department of Commerce, shows the value of exports of roofing slate from the United States, by fiscal years from 1884 to 1904 and by calendar years from 1903 to 1913. No separate record has been kept of the manufactured product.

Exports of slate from the United States, by fiscal years 1884–1904, by calendar years 1903–1913.

1884	$79,464	1899	$1,363,617
1885	51,011	1900	950,543
1886	123,565	1901	898,262
1887	61,047	1902	945,352
1888	97,707	1903	[1] 628,612 [2] 838,683
1889	109,896		
1890	94,048	1904	[1] 726,715 [2] 449,743
1891	84,408		
1892	57,514	1905	408,309
1893	52,012	1906	255,785
1894	37,195	1907	220,995
1895	38,806	1908	197,216
1896	266,385	1909	209,338
1897	780,112	1912	[3] 171,775
1898	1,370,075	1913	226,413

No figures are available for 1910 and 1911, the slate exports not being kept separate from those of other kinds of stone. A large part of the slate exported from the United States goes to Great Britain and Ireland, and in 1912, according to figures published by the Slate Trade Gazette of London, the imports of United States slate amounted to 4,441 tons, valued at £18,133; in 1913 these exports decreased to 2,498 tons, valued at £9,362, or about one-fifth of the slate exported.

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[1] Fiscal year. [2] Calendar year. [3] July 1 to Dec. 31 only.

APPENDIX.

BIBLIOGRAPHY OF SLATE.

The following bibliography is divided into three sections. The first includes only works of a general character, the second special scientific papers and memoirs, and the last works of an economic character.

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GLOSSARY OF GEOLOGIC AND SLATE-QUARRY TERMS.

As this bulletin is intended largely for the use of persons unfamiliar with geologic science, a number of the geologic terms used in it, whose meaning is not self-evident, are here explained, and for the benefit of geologists who may have occasion to use the book some of the terms in use among slate quarrymen are also translated into scientific terms.

AGGREGATE POLARIZATION. The optical property possessed by a thin section of slate cut transverse to its cleavage, which causes it, when viewed through a microscope under polarized light, to appear like a crystal of mica cut across its mineral cleavage. The aggregate polarization of a slate is due to the parallelism of the flakes of mica in the slate, and this, when marked, shows it to be a mica slate and not a clay slate. A very brilliant aggregate polarization, coupled with regularity in size of particles, indicates a high grade of fissility.

ANTICLINE. The arch part of a folded bed.

ANTICLINORIUM. A mountain mass arch-shaped in its general internal structure.

AUTHIGENOUS. Minerals originating chemically within a rock are called authigenous.

BACK JOINT. Joint plane more or less parallel to the strike of the cleavage and commonly vertical.

BATE. False cleavage.

BED. A continuous mass of material deposited under water at about one time.

BLIND JOINT. Obscure bedding plane.

BOTTOM JOINT. Joint or bedding plane horizontal or nearly so.

BRECCIA. Rock made up of angular fragments produced by crushing and then recemented by infiltrating mineral matter.

Brecciated. Applied to a rock made up of angular fragments but not transported.

Clastic. Constituted of rocks or minerals which are fragments derived from other rocks.

Cleavage. Cleavage in a rock is an arrangement of its particles that gives it the property of splitting readily in a certain direction into thin plates. (See on slaty cleavage, p. 33.)

Cleave. Slaty cleavage.

Conformity. When one bed overlies another in parallelism without any disturbance of the crust having affected the lower one before the deposition of the upper they are said to be in conformity.

Creep. Effect of the motion of the continental glacier on the upper edges of a mass of steeply inclined thinly foliated rock, bending the foliation for a few inches or feet from the surface in the direction of the motion of the glacier. Creep may also result from gravity operating on steeply inclined weathered beds.

Diagonal joints. Joints diagonal to the strike of the cleavage.

Dip. The degree and the direction of the inclination of a bed, cleavage plane, joint, etc.

Dip joint. Vertical joints about parallel to the direction of the cleavage dip.

Dike. Molten material erupted through a narrow fissure.

End joint. Vertical joint about parallel to direction of the cleavage dip.

Erosion. The "wear" of a rock surface by natural mechanical or chemical agencies.

False cleavage. A secondary slip cleavage superinduced on slaty cleavage. (See p. 37 and Pls. VII, XI, *A*.)

Fault. A fracture resulting in a dislocation of the bedding or cleavage, one part sliding up or down, or both changing positions along the fracture.

Flints. A term applied alike to quartz veins or beds of quartzite.

Formation. A larger group of beds possessing some common general characteristics or fossil forms differing from those of the beds above and below.

Grain. An obscure vertical cleavage, usually more or less parallel to the end or dip joints.

Hards. Term applied to beds of quartzite or quartzitic slate.

HCl. Hydrochloric or muriatic acid.

Hogbacks. Shear zones. (See p. 44 and Pl. VIII.)

Hygroscopic. Term denoting the absorption of moisture by a rock or chemical compound.

Isoclinal. Folds with sides nearly parallel are said to be isoclinal.

Matrix. Term used in microscopic descriptions of slate, etc., to denote the chief substance of the slate itself, apart from the various mineral particles or crystals it may inclose.

Metamorphism. The process, partly physical, partly chemical, by which a rock is altered in the molecular structure of its constituent minerals and in their arrangement.

Overlap. Where, owing to the depression of a coast and the consequent landward shifting of the shore line, the later marine sediments cover up the extremities of the older ones, they are said to overlap.

Pitch. The inclination of the axis of a fold of rock.

Post. A mass of slate traversed by so many joints as to be useless. The term is also used to denote bands of hard rock.

Pseudomorph. A mineral that has assumed the crystal form of a different mineral as the result of the partial or entire alteration or replacement of the original mineral through chemical processes.

Quartzite. A sandstone in which the grains are held together by a siliceous (quartz) cement.

RIBBON. A line of bedding or a thin bed appearing on the cleavage surface, sometimes of a different color; or a small bed of quartzose or calcareous material either crossing or parallel to the cleavage. If such ribbons are separated by beds of slate too thin to be worked, the ribbons and the small beds are together designated as "ribbon."

SCULPING. Fracturing the slate along the grain; that is, across the cleavage in the direction of the dip.

SERICITE. A ribbon-like or fibrous form of muscovite or potash mica.

SHEAR ZONE. Hogback. (See p. 44 and Pl. VIII.)

SLANT. Longitudinal joint more or less parallel to cleavage and commonly slickensided.

SLATY CLEAVAGE. See CLEAVAGE.

SLICKENSIDES. Surface of bed or joint plane along which the rock has slipped, polishing and grooving the surfaces.

SLIP. Joint crossing the cleavage, but of no great continuity. Many slips are fault planes.

SLIP CLEAVAGE. Microscopic folding and fracture, accompanied by slippage; quarrymen's "false cleavage." (See p. 37 and Pls. VII, XI, *A*.)

SPLIT. Slaty cleavage.

STRATUM. A bed.

STRATIFICATION. Bedding, in distinction from cleavage.

STRIKE. Direction at right angles to the inclination of a plane of bedding, cleavage, jointing, etc.

STRIKE JOINT. Joint parallel to the strike of the cleavage.

SULPHUR. Quarrymen's term for iron pyrites.

SYNCLINE. The trough part of a fold of rock.

SYNCLINORIUM. A mountain mass, in general internal structure trough-shaped.

THICK JOINT. Two or more parallel joints between which the slate has been broken up or decomposed.

TILL. A mixture of clay and pebbles deposited by glaciers.

TOP. The weathered surface of a slate mass or the shattered upper part of it.

UNCONFORMITY. If the lower one of two contiguous deposits affords evidence of having been exposed to atmospheric erosion before the deposition of the upper one, there is said to be an unconformity between them.

VEIN. When correctly used, denotes a more or less irregular, in places ramifying mineral mass, commonly of quartz, with calcite, etc., within the slate. Such veins are called veins of segregation, to show that they consist of matter collected from the adjacent rock by solvent waters. But, as generally used by slate quarrymen, "vein" is the equivalent of bed or stratum.

WAVERS. Annelid trails.

WILD ROCK. Any rock not fit for commercial slate.

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